ROYAL GEOGRAPHICAL SOCIETY
1830

HINTS TO TRAVELLERS.

NINTH EDITION.

VOL. I.

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HINTS TO TRAVELLERS

SCIENTIFIC AND GENERAL

EDITED FOR THE

Council of the Royal Geographical Society

BY

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Instructor in Surveying and Practical Astronomy to the Royal Geographical Society.

NINTH EDITION

REVISED AND ENLARGED

VOL. I.

SURVEYING AND PRACTICAL ASTRONOMY

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PREFACE TO THE NINTH EDITION.

THE eighth edition of 'Hints to Travellers,' edited by Mr. John Coles and published in 1901, being exhausted, it has become necessary for the Council of the Royal Geographical Society to issue a new edition. As the days of the pioneer explorer of the old type are fast drawing to a close, and more exact surveys are required than were formerly considered sufficiently accurate for the traveller in unexplored regions, a large amount of new matter has been added to the first volume, and many alterations made. However, as it did not seem advisable to increase the size of the work to any great extent, some of the more approximate astronomical methods and less important tables have been omitted. Among the former may be mentioned the Lunar Distance and Moon Culminating Star methods of determining the longitude; and of the latter the tables of the Sun's Declination and Right Ascension, and Equation of Time, which were only given roughly. As these are to be found in the 'Nautical Almanac,' with which every geographical surveyor *must be furnished*, they could be well dispensed with. Another table omitted in this edition, which occupied considerable space, is that of Proportional Logarithms. If these are required they can be readily found from the Common Logarithms. An introductory chapter on geographical surveying in general, suited to modern requirements, has been added, and the section on 'Geographical Surveying,' with many other parts, have been entirely rewritten. Fresh astronomical examples, most of them from observations taken by my former students, have been furnished, whilst the

forms for computation have in some respects been altered to give greater accuracy in results.

The thanks of the Council are specially due to the firm of J. D. Potter for again granting permission to reprint many of the tables, and some of the Definitions of Practical Astronomy, given in Raper's well-known 'Practice of Navigation.'

The various sections in Volume II. have been carefully revised by their respective authors, or where this has been found impossible owing to death or some other cause, by some experts well qualified for the work, whose names appear at the heading of the sections. A new section on Archæology has been written by Mr. D. G. Hogarth, to which is added much that was useful in Mr. A. P. Maudslay's notes on Paper Moulding. Dr. W. L. H. Duckworth has added important notes to the Anthropological Section. A separate pamphlet on Outfit, written by Dr. C. F. Harford, who has also kindly revised the important Medical section of these 'Hints,' can be obtained at the Society's office. When the eighth edition of 'Hints to Travellers' was published, it was decided to issue the Hints on Outfit separately, because these are principally for the guidance of travellers in the selection of their equipment before leaving home, and are not likely to be so useful in the field of exploration, for which the 'Hints' are intended.

I am greatly indebted to the War Office for the kind permission given me to make use of the excellent 'Text Book of Geographical and Topographical Surveying,' which has been most valuable; and to Major C. F. Close, C.M.G., R.E., and Mr. D. G. Hogarth, for the trouble they have taken in looking through the proofs.

The earlier editions of these 'Hints,' which have proved of such value to travellers and explorers in all parts of the world, were developed from a small pamphlet under the able superintendence of Mr. J. Coles; and it is hoped that now, in its present form, the work may prove even more serviceable.

E. A. Reeves.

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HINTS TO TRAVELLERS.

VOL. I.

SURVEYING AND ASTRONOMICAL OBSERVATIONS.

By E. A. REEVES, *F.R.A.S., Map Curator and Instructor in Surveying and Practical Astronomy, R.G.S.,* AND OTHERS.

INTRODUCTORY REMARKS ON GEOGRAPHICAL SURVEYING AND PRACTICAL ASTRONOMY SUITED TO PRESENT REQUIREMENTS.

THE advance of geographical exploration and discovery during the last fifty years has been so rapid and continuous that there remain at the present time few parts of the earth's surface that are entirely unknown. With the exception of the polar regions, and certain very limited areas in Central Asia, Africa, and the other continents, pioneers of Western civilisation have penetrated into all the remote parts of the world, and brought back with them some account of the lands they have visited, from which it has been possible to fill in the large blank spaces that were but a few years ago so conspicuous upon our maps, although in many cases the cartographical material from which this has been accomplished is far from satisfactory.

The days of rough route-mapping are practically past. A man who only makes a hurried journey through some imperfectly known district, without proper instruments or previous training, and who is able, consequently, only to bring back with him a rough prismatic compass sketch

of the route he has taken, unchecked by astronomically determined or triangulated positions, will, at the present time, find that he has not rendered any great service to geography. That sort of work might be all very well in the early days of exploration, but what is wanted now is something better and more reliable—survey work which will take the place of first approximations and rough sketches, and which, if not possessing the extreme accuracy of a complete trigonometrical survey, shall at least have some scientific basis, and be far more reliable than anything previously existing. It is therefore considered advisable that by way of introduction to this new edition of the 'Hints to Travellers' a few general remarks should be given as to how this can best be accomplished, and the lines upon which a geographical surveyor, who finds himself in some imperfectly mapped region of the earth, can proceed with the prospect of doing really useful work.

With the recent rapid advance in the construction of telegraph lines, railways, boundary delimitations, and other surveys of considerable exactitude, the regions of the earth's surface where an explorer is likely to be so situated that he will find no fixed points to which his mapping can be adjusted, or which will serve as starting-points for his surveys, are becoming fewer every year, and it is to be hoped that in a time not far distant lines of triangulation will be carried across all those regions of the earth that are likely to be settled by Europeans. In Africa remarkable progress is already being made in this direction, and, what with the transcontinental telegraph line, the important geodetic chain of triangles now being undertaken in Rhodesia; the Sudan, Uganda, Rhodesia, and other railways, and the many boundary surveys; the traveller who is starting upon a surveying expedition in that continent will, even at the present time, stand a good chance to find some points upon which to base his work—points which have been fixed with greater accuracy than he will be likely to obtain during a hurried journey, and with the small portable instruments generally carried on such occasions. Then, again, in the case of Asia, full inquiry should be made as to what survey work has been done in the region to be visited, especially anywhere near the transfrontier regions of India, where points have been fixed with considerable accuracy by triangulation. The same remarks apply to other parts of the world, although of course there are still regions in all continents, except perhaps Europe, where nothing

at all reliable in the way of survey work has yet been attempted, and in which the traveller will be thrown entirely upon his own resources, and have to fix the position of places by the best means possible under the circumstances in which he may be placed.

There are two methods of procedure open to a traveller who has a knowledge of practical astronomy and surveying. The first is that of triangulation, or else of making use of points already accurately fixed, extending the map by triangulation from these, and filling in detail between them; and the second, the independent method which has to be resorted to when no fixed points are available, and in which case positions of important stations have to be determined chiefly by astronomical observations before the filling in of detail can be undertaken. Upon these two methods a few general remarks will now be made, while fuller information will be found in the different sections of these 'Hints.'

Where prominent hills or landmarks are available the former method should be adopted, as it is far more likely to yield good results under ordinary circumstances than the latter, and therefore this shall be considered first. But, to begin with, there are important preliminary matters to be attended to, which apply equally to whatever method of survey is followed, such as the selection of instruments, the most suitable scale and projection for work in the field, and other points which should be fully discussed and settled before commencing work. As regards instruments, first and foremost in the geographical surveyor's outfit comes the transit theodolite. There may be times when it is impossible to carry a theodolite, and the more portable substitute, the sextant, has to take its place; but it is strongly recommended that a good theodolite should be taken when it is at all practicable. The difficulty concerning its carriage is often more imaginary than real, or if it actually exists, it can be frequently overcome by a man who is intent upon doing good work. Other things are often taken of greater weight and bulk, but of much less importance, than a 5 or 6-inch transit theodolite.

A good theodolite is without doubt the instrument for a surveyor, not only because it is more generally useful to him for all kinds of work, but on account of the greater accuracy of the results obtained. To take latitude as an example, with a 5-inch theodolite, a good observer, with an instrument of the most approved pattern, ought certainly to get a mean result from two sets of circummeridian altitudes of north and south

stars that will not be more than one or two seconds in error, but with a sextant the latitude will probably be at least 10 seconds wrong, even when the altitudes have been taken with the best instrument and by a most experienced observer, although, of course, results sometimes come out nearer than this. When a sextant is the only instrument available for astronomical work, the most serviceable one is a 6-inch, reading to 10 seconds, to be used in conjunction with a folding roof, or ordinary roof, mercurial artificial horizon.

The transit theodolite most suitable for geographical surveyors is doubtless a 5 or 6-inch, reading with micrometers, either of the ordinary pattern, or Reeves's tangent-micrometers, on both vertical and horizontal circles to 5 or 10 seconds, and by interpolation to the nearest second; or failing these, by verniers to 10 seconds. It should, of course, possess a complete vertical circle, and care should be taken to see that the telescope reverses freely when using either the direct or diagonal eye-piece set at focus. The principal level should be fitted to the vernier arm of the theodolite, and not on the telescope, as is the case with some instruments. This is most important for exact results, to obtain which the level readings have to be noted, both for "face right" and "face left" observations, and a correction for dislevelment applied to the mean altitude. When the level is on the telescope itself, this is impossible. The diaphragm of the telescope should be fitted with a horizontal wire and at least three vertical wires or cuts on glass, which should be well illuminated for star work, and there should be only three levelling screws. The trough compass needle of the plane-table kind, which should be made to reverse, is much to be preferred to the circular compass usually fitted to the theodolite, but even this is often far from what it should be, especially in reference to the method of setting. It is true that the magnetic bearing, when the needle has been made zero, can be read with an appearance of great accuracy by means of the verniers, but it is often with an appearance of accuracy only, as the means of setting the needle to zero is usually extremely rough. Several improvements have, however, been made recently which it is to be hoped will facilitate greater accuracy; for although it is true that no good surveyor will make his map to depend upon the magnetic needle, yet there is no reason why he should not bring home with him valuable determinations of the magnetic declination in the regions visited.

A small 4-inch transit theodolite, by Casella, is now made specially for travellers who cannot carry a larger instrument. This is fitted with Reeves' tangent-micrometers cut to 10 seconds, which can be subdivided by estimation to the nearest 2 seconds (*see* p. 39).

For the first method of survey, previously referred to, the instrument next in importance to the theodolite is the plane-table. This should be as simple as possible, consistent with accuracy. It should not be unnecessarily large or heavy, and no attempt should be made to combine it with a theodolite. At the same time a simple telescope (with cross-wires), which can be moved vertically through a few degrees, is a great assistance in distinguishing distant points, and for sighting on to points of considerable difference of altitude. A small clinometer or vertical arc to give approximate angles of altitude will often be useful. For ordinary purposes a table measuring about 2 by 1½ feet is perhaps the most serviceable, but for mountaineering expeditions one much smaller and lighter could be employed. The plane-table deserves to be more generally used than it has been, as even for traversing it gives better results than a prismatic compass. Of course, there are other instruments a traveller should take with him, such as half-chronometer watches, and a portable mercurial barometer, boiling-point thermometers, aneroids, &c., for determination of altitudes, and these are dealt with in their proper places in the following 'Hints.' As regards the watch, this should be of first-class manufacture; that in a water-tight case of the pattern recommended by the Royal Geographical Society is perhaps the most suitable and reliable, although it is quite a mistake to imagine that any chronometer or watch will keep a perfect rate when travelling, and even if observations are taken as often as possible to obtain the rate it has been found practically impossible to carry Greenwich Time with the accuracy required for good results in longitude. Still, good watches are important, as *differences* of longitude can be obtained by them, in conjunction with careful observations for local mean time, with considerable accuracy, especially if the route passes between the places more than once, and careful observations have been taken for rate.

The scale and projection most suitable for work in the field next call for consideration. The former must of course depend, in great measure, upon the area to be mapped, the time that can be given to the work, the

amount of detail required, and several other considerations; but for ordinary purposes of geographical mapping, perhaps the most serviceable is that of 1:250,000, or 3·94 statute miles to an inch. This has been adopted at the Topographical Section of the War Office as their usual scale for work in the field, and has proved to be satisfactory. It differs but little from the 4-miles-to-1-inch scale adopted for transfrontier work in India. This scale admits of the leading features of a country being represented, and at the same time enables a surveyor to include a fairly large area upon his plane-table sheet. Where more detail is required, the scale of 1 : 125,000, or little larger than 2 miles to an inch, has been found to answer well. But whatever scale is adopted, it is well that it should be some proper multiple of the 1 : 1,000,000, which is now generally taken as the standard or unit for all maps. In connection with this question of scale, it is most important that a geographical surveyor should learn how to generalize the physical features of a country, and be able to represent, in the first place, the leading characteristics of the region to be mapped, without giving undue prominence to detail, the amount of which must necessarily depend upon the scale adopted. This is not such an easy matter as it may appear at first, and requires considerable previous training. It is not at all unusual to find that a man has crowded his map with small hills and tiny streams, giving them an importance which they do not really possess, and at the same time altogether omitted to bring out the leading features of the region, which he has, indeed, often quite failed to grasp. One essential thing for a geographer, as for all students of nature, is to learn to generalize, and for this previous training is absolutely necessary. Here a man who has some knowledge of geomorphology and physical geography has the advantage, and is likely to bring home a far better map of a country than one who has not.

The next question to be considered is that of the projection, for unless the area to be surveyed is small, some proper projection should be employed. This is a matter that has received considerable attention of late, and the general conclusion is that that usually known as the "Survey of India Projection" is, taking all things into account, the most suitable to adopt for plane-table work. This projection is described on p. 89 and tables for its construction given on p. 287.

So far all that has been said applies equally to the work of the

surveyor, whether his map is to depend upon points previously determined, or he has to undertake an entirely independent survey; but a brief outline of the process which it would be advisable to follow in each case will now be given.

In the first place, having made his projection, and constructed his diagonal scales—one of miles and decimals of a mile—and others to read seconds and decimals of seconds of latitude and longitude—the surveyor proceeds to place upon his plane-table sheet, in their exact latitudes and longitudes, as many of the fixed points as are likely to be of service to him. He should now set up his theodolite at one of the fixed points, or, if this is quite out of the question, should set it up in some position from which he will be able to extend his survey in the line in which he is about to travel, and take angles to the fixed points from which he will be able to compute his new position. Making one fixed point zero, rounds of horizontal angles, both "face left" and "face right" and reading both A and B verniers, should now be taken, and the vertical angles of elevation and depression observed, to all the more important distant peaks and other prominent objects, being careful to note the level readings. This same operation should, if possible, be repeated at several of the fixed points, and the surveyor will then be furnished with the means of computing, with considerable accuracy, the latitude and longitude and relative heights of the new points observed. When computed, the latitudes and longitudes of these points should be tabulated.

It sometimes happens that it is impossible to do more than make one fixed point a starting-point, in which case the theodolite should be set up in this position, observations taken for latitude, and making some distant point in the line of march, which can afterwards be visited, the zero, a careful round of angles should be taken to all prominent objects that are likely to be seen later on from another position. Now, before the theodolite is moved, with the same distant point still zero, take careful observations for the azimuth of the distant point made zero, which can be done by east and west stars, reading at the same time as the altitudes the horizontal angle between the object and the star. From these observations it will be possible to compute the azimuth of the zero line with considerable accuracy. Later on when the point made zero is reached, set up the theodolite, and, sighting back at the station left, which must now be made zero, repeat the operation. If it

be found impossible to go to the point from which was made zero at the first station, another point from which the first station is visible must be selected, the latitude must be found, and making the first point zero, a back azimuth observed by east and west stars. As before stated, the latitude resulting from these observations, if carefully taken with a good 5 or 6-inch theodolite, should not be more than one or two seconds in error. With the latitudes of the two stations and the azimuths of the line joining them known, it is possible to compute, with considerable accuracy, the distance between them, and their difference of longitude. This, which is generally known as the Latitude and Azimuth Traverse method, is described on p. 117, and is certainly the best means of obtaining an astronomical base-line for a survey, and when it is impossible to get a base by actual measurement or extension of triangulation, it should be adopted, although the value depends a great deal upon the general direction of the route, for on an east-and-west route the method could not be employed. By this method a survey can often be continued for a considerable extent, the operations being repeated from other stations, and rounds of angles again taken. (For particulars see pp. 117–121.) The map should, however, be checked by measured bases wherever possible. When at all practicable the length of a base-line should be obtained by actual measurement. A base of about a mile can be measured three times over (to give a mean value) easily in a day, while from the two ends of it rounds of angles are taken with the theodolite, latitude and azimuth being only determined at one end. Observations can be computed at night, after being taken as soon as the stars are visible, and latitudes and longitudes (latter assumed at the base end) of observed points ready for projection on plane-table in early morning. As the party moves on past the points observed, a new base should be measured, and its position interpolated by computation from the old points (even a plane-table interpolation is good enough for the topographer), fresh points observed, computed, plotted, and utilized for topography; and so on, measuring bases at every opportunity. In this way a party of two surveyors and five or six chainmen can move at marching pace (say, 20 miles a day), and keep up continued mapping on favourable ground when good points are plentiful and visible. When it is impossible to see more than a short distance, traversing with the plane-table must be resorted to, distances being obtained with pedometer or perambulator, checked by latitudes each

night. In this way mountain-climbing is reduced to a minimum. The vertical angles will furnish the means of obtaining the relative altitudes of different stations, care being taken to correct for curvature and refraction. The system of exact contouring is generally out of the question, except in large-scale plans of small areas, and the general indication of the relief by horizontal "form lines" is, perhaps, the best to adopt, with as many fixed heights as possible given, not only of hills, but of valleys and low-lying lands as well.

So much for an outline of the theodolite part of the work, but now for the plane-table. With this instrument the surveyor should proceed to fill in detail between the triangulation points, starting from one of the fixed positions, and orienting his table by others, if possible; but where this cannot be done, he must find his position and orient his board by one of the applications of the three-point problem. Unless absolutely unavoidable, the magnetic needle should not be employed for this purpose, although it is very useful to get the first approximate orientation of the plane-table, and is always a good check against mistakes in the identification of points. Having determined his position and oriented the board, the plane-tabler should proceed to fix as many other points as possible, drawing rays to all prominent objects, bends in rivers, etc. Even if the intersection of two rays drawn to any distant object should give a very bad angle, it is often well to draw the rays, for they will give a rough idea of the position, and assist in the identification of the point when it is seen from another position later on, which is often a very difficult matter, owing to the various forms an object, such as a distant peak, will assume when seen from different positions. The plane-table surveyor should not, however, be content with merely fixing points; another important part of his duty is to sketch in the topographical features of the district, and this should be done as far as possible on the spot, and at the time—not afterwards from rough notes and sketches. These latter are all very well, and will assist in making the final map, but the leading features should be drawn at once upon the plane-table.

We now come to the other part of the subject, in which it is supposed that the explorer is so placed that he cannot triangulate, has no fixed positions to work from and has to depend entirely upon his own determinations of latitude and longitude. The suggestions made here will be brief as these matters are dealt with later on in the 'Hints.'

On arriving at his field of operation the first thing a traveller has to do is to get a good determination of the latitude of some place with a theodolite, which will serve as a starting-point for his proposed survey. There ought to be little difficulty about this, especially as it is not necessary to have exact Greenwich time for the purpose. The latitude should be fixed by circummeridian altitudes of north and south stars, and the altitudes, which must never be low, should, if possible, be taken both east and west of the meridian in each case, the hour angles not exceeding fifteen minutes. The latitude resulting from the meridian altitude will serve as the approximate value necessary for the more exact method of computation.

It is most important that all observations should be balanced, and therefore the mean latitude arrived at from the results obtained from several stars passing the meridian to the north and south of the zenith should be that finally adopted.

Having obtained the latitude, the next thing is naturally to find the longitude, and this is a far more serious business. The best watches and chronometers, notwithstanding their many improvements, cannot, when carried overland, be depended upon to keep a rate sufficiently reliable for giving the longitude direct from Greenwich with the accuracy now required, and it is better not to attempt anything more than differences of longitude between places on the route. True, careful observations may be taken for rate, but even then the difficulty is not anything like overcome, and the wasted labour and disappointment to travellers who have trusted to their watches for Greenwich Time is often lamentable. The best watch that a traveller can take with him is one of the R.G.S. pattern, a half-chronometer in water-tight case as described on p. 52; but he must not rely implicitly on this, and should, if possible, take at least three of them. It is generally admitted now that if a traveller is away from all telegraphs, and has no points the longitudes of which have been fixed, and no means of obtaining Greenwich Time apart from his watches, the best thing he can do is to get differences of longitude between the various stations upon his route, by triangulation, or the Latitude and Azimuth method previously described; or, failing this, to fix the relative longitude of places in reference to one station, which should be taken as the standard, by the "meridian distance" method described on p. 238. By so doing, the

longitudes on his map will be relatively correct, and all that is required is that later on one of the positions should be accurately fixed. Whenever at all possible, the difference of longitude between the places should be determined more than once, but this generally means that the distance between the places has to be traversed several times, which is, of course, often out of the question. The observations recommended for Local Mean Time in connection with longitude observations, or for rating purposes, are separate sets of altitudes of east and west stars, accepting the mean result as correct, or the star equal altitude method, several stars of an altitude greater than 40° being taken at different times. The Local Mean Time resulting from either of these methods has been found very satisfactory when the observations have been carefully taken. Of the so-called absolute methods of obtaining longitude, or observations from which the Greenwich Mean Time can be found, there is only one that can with any confidence be recommended to the geographical surveyor—that is an occultation. The observation is simple, although a good telescope is necessary, and great accuracy is required in noting the time by the watch of the occurrence of the occultation. A disappearance usually gives a better result than a reappearance, and when the disappearance takes place on the dark side of the moon, at about first quarter, very fair results are often obtained, say, with an error of longitude varying from 30″ to 1′ 30″. The computation is necessarily lengthy, but the method given in these 'Hints' is about the shortest and simplest of them all, and it can be relied upon for its accuracy, if the moon corrections obtainable from Greenwich Observatory are applied. Colonel Grant's ingenious method of predicting occultations, now somewhat shortened by Mr. Crommelin, has much facilitated the computation of the prediction. The method of obtaining telegraphic differences of longitude is given on p. 242. Wireless telegraphy will possibly come to our aid in the matter of fixing longitudes before long.

Photographic surveying has not been referred to. Doubtless there are times when this method is useful for obtaining rapidly additional detail for filling in a map, but it can, of course, never be supposed to take the place of theodolite work, nor to supersede the plane-table. Under certain conditions it has proved serviceable, specially in mountainous regions, when the peaks are often obscured by mists, and notes are given on this subject on p. 171. With a photo-surveying camera views may

be taken in a few minutes that will afterwards furnish the means of fixing a large number of peaks upon the map with more or less accuracy. Photographic surveying is, after all, but a form of plane-tabling, and depends equally on triangulation, the chief difference between the two methods being that with the plane-table sights are taken to the objects themselves in nature, whilst with the photo-survey method the plane-tabling is done afterwards, in the office, from the representations of the various peaks upon the photographs. It stands to reason, whatever value the latter method may have under certain circumstances, that errors are very liable to creep in, and that the plane-table should, under ordinary conditions, give the best results. For photographic surveying, as employed by the traveller, what is wanted is, not an elaborate and costly combination of camera and theodolite, but some simple and cheap arrangement that can be employed in connection with an ordinary camera, which will enable a traveller to take photographs that are both interesting and instructive as representing the geographical features of the country, and at the same time can be employed for filling in his map.

It is not enough for a surveyor to be able to fix points, he should also be able to give a correct representation of the characteristic features of the country, and not trust entirely to a draughtsman at home to do this afterwards. It is doubtless true that comparatively few men would ever make really good draughtsmen, but training has a great deal to do with the matter. There are persons who are well able to interpret the leading features of a region, and can fix positions with considerable accuracy, but have not the slightest idea of map-drawing, and consequently the rough sketches they send home are often almost unintelligible. The draughtsman, who has never been out of England perhaps, cannot be expected to give such a faithful representation of the features of the region explored as the surveyor who has been in the country, and often a map suffers much in accuracy for this very reason.

In conclusion, stress should be laid on the importance of proper training for this work, for it is a great mistake to think that the necessary knowledge can be acquired from a few short lessons.

A specimen of a topographical map on the scale of 1:250,000, to serve as a general guide as to the character of map to be produced, faces p. 200.

PART I.

PRACTICAL ASTRONOMY AND SURVEY OUTFIT.

The following list of instruments is given as a general guide in making a selection, and the choice must necessarily depend upon the character of the work to be done, the facilities of transit and the funds available for the expedition. All instruments should be of the best manufacture, and before purchasing them they should be thoroughly tested by experts, and whenever possible sent to the National Physical Laboratory for verification.

Theodolite—

The theodolite is in some respects the most important instrument. It should be a transit theodolite with complete vertical circle of 6-inch or 5-inch diameter.* Both vertical and horizontal circles should be divided to 10′, and it should be possible to read by means of verniers to 10″ or with micrometers, with drums divided to 5″ or 10″, to single seconds by estimation. There should be at least two verniers or micrometer readers to both the vertical and horizontal circles, and these should be clearly distinguished from each other by letters. The principal level should be attached to the vernier or micrometer arm, and not on the telescope. Its divisions should be small, and it should be carefully divided from 0 in the centre to at least 20 towards each end. There should be only three levelling screws, and the tripod should

* A light 4-inch theodolite is now made by Casella, fitted with Reeves's tangent-micrometer divided to 10″. It is very useful where weight is a great consideration, and it is impossible to take a larger instrument.

have an adjustable centering arrangement for bringing the plumb-line exactly over a mark in the ground. It is a convenience to have an extra micrometer eye-piece which can be fitted to the instrument when required, in place of the ordinary eye-piece, for bar subtense work. As so much trouble and annoyance is frequently caused by the webs in the diaphragm breaking, fine cuts on glass are to be preferred to spider webs for ordinary work, or if the diaphragm should be fitted with spider webs, an extra diaphragm with cuts on glass should be taken. There should be three vertical lines or webs on the diaphragm and one horizontal, although for tacheometer work another diaphragm is sometimes carried with two horizontal wires arranged to include exactly one foot in a distance of one hundred feet. There should be a good diagonal eye-piece, and it is most important to be able to reverse the telescope with this and any other eye-piece set at focus. Special attention should be paid to the means of effectually illuminating the field for star work, as this is often neglected by the maker. The tripod-stand should be rigid and firm. For further particulars regarding theodolites see p. 28. The weight of a 5-inch micrometer theodolite such as here described is about 40lb., whilst its stand weighs about 12lb.

Sextant—

Whenever possible a theodolite should be used in preference to a sextant, but as the latter instrument is lighter and more portable it can sometimes be carried when a theodolite is quite out of the question. The sextant should be of 6-inch radius, light in weight, by a first-rate maker, divided on platinum or silver, to ten minutes, to read with vernier to ten seconds. It should have a moveable ground-glass screen in front of the reading-off lens, to tone down a glaring light. The handle must be large and convenient; the box capacious enough to hold the instrument with its index clamped to any part of the arc, and the receptacle for the inverting telescope long enough to allow of it being put into the box when set at focus. The telescope should fit into its collar by means of a split thread, and Reeves's endless tangent-screw (Cary) is a convenience, and saves time and trouble.

Mercurial Artificial Horizon—

One of the ordinary form with folding roof is to be preferred, as it is less likely to be disturbed by wind. The Artificial Horizon devised by the late Captain George, R.N., is compact. Casella also makes a very convenient pattern. An iron bottle of pure mercury should be carried as a reserve. (*See* p. 51.)

Base Line Measuring Apparatus—

The "Invar" tape apparatus with tripods for supporting it in a horizontal line, &c., is perhaps the best for topographical surveying. (Mr. Agar Baugh, 92, Hatton Garden, W.C., is the maker.) Very accurate results have been obtained with the Järderin apparatus (Stockholm). Ordinary steel tapes, 100 feet in length, are, however, usually carried, and if care is taken with the alignment and to keep them taut and horizontal they answer very well for ordinary purposes, if the base is measured several times and a mean taken.

Watches—

A keyless silver half-chronometer watch, not too heavy, with an open face and a second hand. The hands should be of black steel, long enough to cover the divisions. The divisions should be very clear and distinct. It is important that the second hand should fall everywhere truly upon the divisions. If possible at least three such watches should be taken, and one or two "split second" stop watches will be found convenient for taking times of observations. It is only necessary that these latter should go for a short time without appreciable error, as they are controlled by the standard watch, or chronometer. Spare watches should be rolled up separately, each in a loosely-wrapped parcel of *dry* clothes, and they will never come to harm; they should be labelled, and rarely opened. The immediate envelope should be free from fluff or dirt. Covers of chamois leather should be washed before use. Spare watch-keys should be taken. (*See* p. 52 for further particulars.)

Chronometers are designedly omitted from this list, on account of the proved difficulty of transporting them overland without injury, and the frequent disappointments they have caused, even to very

careful travellers. They are excellent for river expeditions, or whenever they can be kept on board a boat. For telegraphic determination of longitude box chronometers are necessary, for which purpose one should be rated to go sidereal time.

Plane Table—

The plane-table should be of simple construction, but telescopic sights, instead of the ordinary alidade, are a great advantage for long distance points, and when there is a considerable difference of height between the objects. The table itself should be properly "framed" and the tripod rigid, but not unnecessarily heavy. It is an advantage to have the board fitted with a slow motion screw by which alignments can be made with greater accuracy. At least two complete plane-tables should be taken, and if ordinary alidades are used, also spare horse-hair for the sight vanes. For mountain work a very light form of plane-table will be required. Plane-tables should be carried in strong canvas bags with leather-covered corners, and furnished with straps, so that they can be carried like a knapsack. For information as to form of construction and uses, *see* pp. 55, 124.

Photographic Survey Camera—

The Bridges-Lee pattern is doubtless the best suited to the requirements of the geographical surveyor. (For particulars, *see* p. 172.) Photographs taken with a good ordinary camera can often be used to supplement the work of the plane-table and fill in detail, if the camera can be accurately levelled, and some arrangement is provided whereby the horizontal and central vertical lines can be indicated upon the plate. The focal length of the lens should be known.

Ranging Rods and Levelling Staves—

A dozen or more, 10 feet long, should be taken. The scale of feet and fractions of feet should be clearly marked in different colours.

Telescope—

This is required for observing occultations of stars (*see* p. 245). As some of the stars occulted are very small, and often difficult to

see, especially when the moon is bright, a fairly large telescope should be taken. It should have an object glass of at least 2½ inches clear aperture, and should be furnished with a Kelner eye-piece of not less magnifying power than 60, with additional eye-pieces giving powers up to about 120. The tripod-stand should be rigid and firm, and there should be slow motion screws for moving the telescope both in azimuth and altitude. It will also be found convenient if, in addition to the stand, an arrangement is provided by which the telescope can be screwed firmly into a tree or other support. A convenient form of telescope for occultations is made by Cary, Porter & Co. This is in two sections, and when packed in its case is not very bulky.

Subtense Instrument—

The Indian Survey Subtense Instrument, with two movable micrometer wires, and a 10 or 20 foot rod, as described on p. 58, is better suited for geographical work than the ordinary tacheometer with fixed wires giving distances by reading off the feet and fractions of a foot on a levelling staff by the ratio of 1 in 100, for the reason that the discs can be more easily seen at long distances than the figures on a staff. Messrs. Troughton and Simms make an excellent instrument of the pattern required. When the transit theodolite is fitted with a micrometer eye-piece, to be exchanged for the ordinary one when required, it will answer the purpose of a subtense instrument.

Mercurial Barometers—

The form invented by the late Captain George is perhaps the best for travellers, as it is extremely simple in design, and the tubes being carried empty, there is less risk of breakage. At least one spare tube packed in a rubber-lined brass case should be taken, as well as an extra bottle of mercury and spiral cord for filling. (For description and method of using, *see* p. 63.)

The form of barometer devised by Professor Norman Collie and Captain Deasy is portable, but so far it has not been much used by surveyors. (*See* Vol. II., p. 29.)

Barometers of Fortin's pattern were successfully carried to great

heights by Mr. Whymper, in South America, and some surveyors have done good work with the Boilleau-Mariotti barometer, made by Casella. Care should be taken to see that all barometers read low enough to be used at great elevations.

Aneroid—"Watkin Mountain"—

This instrument can be put into action when required, and, when thrown out of action, is not influenced by the variations in atmospheric pressure. A series of experiments with it were carried out by Mr. Edward Whymper, the results of which were published in *The Geographical Journal*, January, 1899. It has also been used by other travellers, some of whom have reported its performance to be satisfactory, while in the hands of others it has not given good results. For great altitudes it is better to take two, one, for instance, constructed to read from sea-level to 10,000 feet, and the other from 10,000 feet to 20,000 feet.

Hicks, of Hatton Garden, is the maker of the Watkin Mountain Aneroid. (For description, *see* p. 66.)

Aneroid—Ordinary—

Aneroids of ordinary construction should be of large pocket size (2½ inches diameter). They can be obtained graduated up to 20,000 feet at most instrument makers. At great altitudes, however, their records can never be depended on. Ordinary aneroids are useful for differential observations, but *unreliable for absolute* ones; they should be observed, as much as possible, in conjunction with the boiling-point thermometers. Two are required, because simultaneous observations are important. Such observations, taken even at distances of two or three hundred miles apart, are of value, as the areas are usually very large over which the barometer has nearly the same height at the same time at equal elevations.

Hypsometrical Apparatus—

This consists of a spirit lamp and apparatus for boiling, such as described on p. 69. It is provided with an outer tin shield to prevent excessive radiation of heat, and protect from the wind.

There should be two boiling-point thermometers with their Kew certificates, and one ordinary thermometer for taking air temperatures. The whole should fit compactly into a leather case, with a strap for carrying round the shoulders. Care should be taken to see that the boiling-point thermometers read low enough for great elevations.

Thermometers—

Sling thermometers.

Wet and dry bulb thermometers.

A pair of maximum and minimum thermometers, fitted in one case.

Short and stout boiling-point thermometers. (*See* p. 69 for further particulars.)

Ordinary thermometers, which should be graduated from 20° or more below the freezing- to above the boiling-point. For very cold climates, spirit thermometers should be taken.

Solar Radiation Thermometers.

Standard thermometers, at a charge of 1*l.* each, graduated at the National Physical Laboratory, Richmond, Surrey, may be obtained thence, on the application of any Fellow of the Royal Society, or Member of the British Association.

Compasses—

A prismatic compass not less than 3½ inches in diameter, graduated on silver or aluminium, from 0° to 360°. It will be well to have the compass fitted to a light tripod stand, with facilities for placing it horizontal by means of a ball and socket joint.

Two pocket compasses, from 1½ to 2 inches in diameter. The graduations on their cards should run from 0° to 360°, and not twice over from 0° to 180°. A line for True North, temporarily marked on the cards, in the position most appropriate to the magnetic variation in the country about to be visited, may be found convenient. These compasses should be light in weight, have plenty of depth, and be furnished with catches to relieve the needle from its pivot when not used. The needles should work smoothly and quickly: such as make long, slow oscillations

are to be avoided. Cards, half black and half white, are recommended. (*See* p. 71 for further particulars.)

A good boat's compass will be found useful for river work.

Perambulator for measuring distances—

This should be of the simplest construction possible, strong and well made, or it will soon become useless, especially when used over rough ground. All complicated mechanism in the arrangement for registering the distance should be avoided.

Heliostat—

This will often be found useful for signalling purposes, and indicating distant survey points in triangulation. It should be of light portable form, and simply constructed. (*See* p. 73.)

Lanterns—

All lanterns should be made of copper or brass, as, if made of iron, they will affect the compass reading when taking the bearing of a heavenly body at night, and should be constructed for long journeys and hot climates to be used with oil, and furnished with a large wick. A candle lantern is convenient where candles can be carried. See that there is abundant supply of air-holes in the *sides;* these are essential when the lantern is set upon the ground. Also that all the internal fittings can be removed and cleaned, and that they are solidly made, not merely soldered. The lantern for reading verniers should be furnished with a reflector, to throw a clear light forwards and *downwards.* A movable shade of light green glass will be found to be a great improvement, as it prevents the light from dazzling the eyes, and enables the observer to take the reading on the theodolite or sextant with greater ease. A good lantern is *most important.* For general purposes, the Italian Alpine Club lantern is one of the best forms. A small ball of spare wick, oil of the best quality obtainable, and wax tapers, for use on detached expeditions, should also be taken.

Theodolites and sextants are sometimes fitted with small electric lamps for reading the micrometers or verniers. This arrangement answers well in civilised countries where the batteries can be

replenished, but for long journeys through uncivilised regions this is often impracticable. Electric torches are most convenient for reading instruments if fresh charges can be obtained, but this too is often an impossibility. An ordinary bicycle lamp is convenient for reading the arc of a theodolite and sextant.

Pedometer—

Apt to get out of order. If employed, at least three persons should each carry one.

Clinometer—

One of the many simple forms will be found useful for contouring and rough angular measurements.

Abney's level, with a mirror to show where the bubble is when it is held to the eye, serves well as a clinometer.

Rain Gauge, *Anemometer*, and other meteorological instruments should be taken whenever there is likely to be an opportunity of taking observations with them. (For information as to best form, *see* Dr. Mill's article, Vol. II., p. 24.)

Magnetic Instruments—

Observations for the determination of Magnetic Declination, Inclination, and Horizontal Intensity should be made whenever possible. The Declination can be measured with fair accuracy with the long trough compass needle of the transit theodolite, as this, if of the most approved pattern, is made to reverse, and can be set with a microscope. (For instructions as to this observation, *see* pp. 258, 262.) The Lloyd-Creak instrument is portable, and convenient for observing the Inclination and Horizontal Intensity. It has now been thoroughly tested, especially on the U.S. Coast and Geodetic Survey, and found to give very satisfactory results. This instrument is made by Dover & Co., of New Charlton, S.E.

Books, Maps, &c.—

'Hints to Travellers,' published by the Royal Geographical Society.
Trigonometry: Plane and Spherical, with the Investigation of some

of the More Important Formulæ of Practical Astronomy and Surveying. Specially arranged for the use of Students attending the Royal Geographical Society's course of instruction, by E. A. Reeves, F.R.A.S., Map Curator and Instructor R.G.S. A text-book to accompany the 'Hints to Travellers.'

Text-Book of Topographical and Geographical Surveying, by Major C. F. Close, C.M.G., R.E. London: Wyman & Sons. This is the best general text-book on these subjects.

Topographic Surveying, by H. M. Wilson. New York: Wiley & Sons; London: Chapman & Hall. A very complete work, by a surveyor of the U.S. Geologic and Topographic Survey.

Auxiliary Tables to Facilitate the Calculations of the Survey of India. Dehra Dun.

Nautical Almanac for current and future years, strongly stitched in cloth.

Godfray's Treatise on Astronomy. London: Macmillan & Co. A good general book on Practical Astronomy.

Raper's Practice of Navigation. London: J. D. Potter. The Practical Astronomy section and the tables, with explanations, are most useful. These parts can, if desired, be taken out and bound up without the Navigation sections.

Chambers' Mathematical Tables and Practical Mathematics are both useful. London and Edinburgh: W. & R. Chambers, Limited.

Shortrede's Logarithms. London: C. & E. Layton. These tables will be useful for more exact computations. They give at a glance seven place logarithms of sines, cosines, tangents and cotangents of angles to single seconds of arc, and ready means of applying the difference to decimals of seconds.

Molesworth's Pocket-Book of Engineering Formulæ. London: E. & F. N. Spon.

More extended barometric tables than are given in this volume may be procured at the instrument makers or cut out from Guyot's elaborate Meteorological tables, published by the Smithsonian Institution, New York.

Good star maps or star atlas, such as Proctor's.

Properly constructed map projection of the area to be surveyed (*see* p. 89) on the scale of 1 : 250,000 or 1 : 125,000 for plane-

table work, with diagonal scales of miles and others reading to seconds of latitude and longitude.

Blank projection sheets of all parts of Africa on the scale of 1 : 250,000 have been prepared at the Topographical Section of the War Office, and travellers whose survey work is likely to increase the geographical knowledge of any region of this continent may be supplied with the sheets of the regions they are visiting on application.

The best maps obtainable of the country it is proposed to visit.

Admiralty Manual of Scientific Enquiry.

Chauvenet's Astronomy (New York, 2 vols.) is one of the most complete and thorough of the mathematical works on astronomical observations; it is, however, a book for previous study, rather than for reference in the field.

Mapping Instruments—

A small leather pocket-case of drawing instruments, containing, among other things, hair-compasses, drawing-pens, and a rectangular protractor, with scales of chords, sines, tangents, &c., engraved on it.

Marquois's scales, for ruling parallel lines at definite intervals.

Protractors: one circular, of metal, and one of celluloid, of 6 inches in diameter; one of vulcanite, 6 inches, all graduated, like the prismatic compass, from 0° to 360°.

A two feet metal Gunter's scale in case, with diagonal scale of inches tenths and hundredths. It would also be convenient to have engraved upon it a diagonal scale of miles, tenths, and hundredths for the natural scale, or R. F. of 1:250,000. Two dozen artist's pins. Medium size measuring tape, say 50 feet pocket ditto, 2 yards.

Stationery, &c.—

An artist's board, not less than 8 inches by 13, made of light, well-seasoned pine, and what cabinet-makers call "framed," to rule and draw upon.

Blank forms for working out computations, such as used by R.G.S. These forms are kept in type, and copies can be

obtained on application to the Instructor, R.G.S., for the cost of printing.

Plenty of good ordinary paper. Reporters' note-books ruled (not "metallic," for prepared paper is not strong enough, and the leaves of such books are very liable to become torn out and lost; they are also damaged by wet). They should be all of one size, say 7 inches by 4½, or larger, and numbered. A leather pouch, secured to the waist-belt, having a flap buttoning easily over, to hold the note-book in use.

Two (or more) MS. books of strong ruled paper, foolscap size, each with a leather binding; the pages should be numbered, and journal observations, agreements, and everything else of value, written in them.

Survey field books, with double line ruled down centre of page (good ones can be obtained of Rees, Pall Mall). Also field book ruled into three columns for survey traverse, as explained on p. 164.

Angle books for recording astronomical observations, according to specimen on p. 256.

Some sheets of blotting-paper cut up, and put here and there in the books.

Transparent cloth and paper for tracing.

Plenty of brass pens and holders; also fine drawing-pens (steel crow-quills—Brandauer's Oriental pens are very good) and holder.

A. W. Faber's 6 H., F, and B pencils.

Penknives. India-rubber cut up into pieces.

Bottles of indelible ink of various colours.

Ink-powders of a kind that do not require vinegar.

Paints for maps, viz., Indian ink, sepia, burnt-sienna, lake, cobalt, and gamboge, in a small tin case.

A dozen sable paint-brushes of different sizes.

Materials for "squeezes," if travelling where inscriptions may have to be copied (*see* Vol. II., p. 160).

Examination of Instruments.

All important instruments should be tested, and their errors determined and tabulated, at the National Physical Laboratory, Richmond, Surrey. Boiling-point thermometers, aneroids, and other meteorological

instruments, should be tested both before starting and after returning from an expedition if it has extended over a considerable length of time. In the case of thermometers which have been previously examined it has been found that their errors change considerably; for instance, a boiling-point thermometer which was tested in 1884 was found, in five years, to have increased its error at some readings by no less than ·2 of a degree, and in no part of the scale by less than ·1 of a degree. The following are some of the present charges:—Watches, A class, £1 1*s*., B class, 10*s*. 6*d*.; marine chronometers, £2 2*s*.; ordinary thermometers, 1*s*. 6d.; boiling-point thermometers, 2*s*. 6*d*.; maximum and minimum thermometers, 1*s*. 6*d*.; deep-sea thermometer (with pressure test), 5*s*.; solar radiation thermometer, unmounted, 3*s*.; solar radiation thermometer (*in vacuo*, tested under conditions of use), 5*s*.; mountain barometer, with *either* inch or metre scale, 8*s*. 6*d*.; mountain barometer, with *both* inch and metre scales, 8*s*. 6*d*.; aneroid, according to range scales, &c., 5*s*. to 8*s*. 6d.; aneroid, with test for temperature compensation (at atmospheric pressure), 2*s*. 6*d*. extra; hydrometers, 2*s*. to 5*s*.; prismatic compasses, A class, 6*s*., B class, 4*s*. 6*d*.; theodolites and tacheometers (ordinary), 10*s*. 6*d*.; the same with reading micrometers, 21*s*.; telescopes, 3*s*. 6*d*. to 5*s*.; superior sextants, A class, 6*s*. Unifilars, dip circles, and other magnetic instruments are also verified. The carriage of the instruments to and from the Observatory must be paid. Address—"Director, National Physical Laboratory, Old Deer Park, Richmond, Surrey." The establishment lies ten minutes' walk from the Richmond railway-station. Any persons ordering instruments from opticians may direct them to be previously forwarded there for verification. Watches may be deposited in London with the Secretary of the Horological Institute, Northampton Square, W.C. The Laboratory authorities insure apparatus sent for verification against damage by fire, theft, or accident while in their custody, and against risks of transit to and from the Laboratory. They will not, however, be responsible for a sum exceeding £100 on any one instrument or piece of apparatus, unless a letter has been received and acknowledged by them before the instrument is sent, advising that it is being sent, and requesting that it be insured for some definite sum.

Packing.

It is difficult to give general rules, because the modes of transport vary materially in different countries. Inquiry should be made by the intending traveller at the Royal Geographical Society's rooms as to the kind of packing best suited for his special purposes and field of exploration. The corners of all the instrument cases should be brass-bound; the fittings should be screwed, and not glued; and the boxes should be large enough to admit of the instruments being taken out and replaced with perfect ease. Instrument makers are apt to attend over-much to compactness, making as much as possible go into a small box, which can easily be put on a shelf; but this is not what a traveller wants, bulk being rarely so great a difficulty to him as weight. Above all, it is most important that he should be able to get at his instruments easily, even in the dark. He should notice particularly the manner in which the instrument is placed in its box, before taking it out, and in the case of a theodolite, observe the positions of the verniers, and the object end of the telescope; attention to this will prevent much loss of time and possible injury to the instrument. Moreover, a large, light box suffers much less from an accidental concussion than a small and heavy one. Thermometers travel best when slipped into india-rubber tubes in a brass casing. A coil of such tubing will serve as a floor, to protect a case of delicate instruments from the effects of a jar. Horse-hair is of use to replace old packing, but it has first to be prepared by steeping in boiling water, twisting into a rope, and, after it is firmly set, chopping it into pieces. The hairs retain their curvature and act as springs. Instruments travel excellently when packed in loose tumbled cloths. When possible the traveller should supervise the packing of instruments himself. Delicate instruments should be taken personal charge of, and not trusted to makers or others to forward.

Prices of Instruments.

For the convenience of travellers the following list of *approximate* prices of the principal instruments suitable for geographical surveying is appended :—

Transit Theodolites—£35 to £50, according to size and pattern. The latter is about the price of the best 5-inch theodolite fitted with

four reading micrometers. The same theodolite fitted with verniers would be about £38, or with Reeves's Tangent Micrometers, about £45.

Half-Chronometer Watch, in water-tight case, £40.

Stop Watch, for taking sights—ordinary, £2 10*s.*; split seconds, £13.

Box Chronometer—£30.

Sextant (6 inch)—£12 12*s.* to £14.

Artificial Horizon—£5.

Base Line Apparatus—Invar Tape apparatus, complete, about £70.

Plane Table—All prices between £5 and £16 16*s.*, according to size and pattern. The latter is the price of the plane-table shown on p. 58, with Reeves's folding telescopic alidade and slow motion for table.

Photographic Survey Camera—£45 to £50.

Telescope for occultations—£25 to £35.

Subtense Instrument (Indian Survey pattern)—£20.

Mercurial Barometer (George's pattern, with spare tubes, &c., complete in case)—£12 to £15.

Aneroid—£5 15*s.*

Hypsometrical Apparatus, with two boiling-point thermometers—£5.

Thermometers—Ordinary, 12*s.* 6*d.* to £1; maximum and minimum (pair in case), £2 10*s.*; wet and dry bulb (pair in case), £2 10*s.*; boiling point, £1 5*s.*

Compasses—Prismatic, £4 10*s.*; pocket, £2.

Perambulator for measuring distances—£4 to £7.

Heliostats—£4 10*s.* to £10.

Pedometers—£1 to £2.

These prices are merely intended as a rough guide, and must not be accepted as authoritative.

There are several firms of really good and reliable instrument makers in London, such as Messrs. Troughton & Simms, Cary, Porter & Co., Casella, Cooke, Stanley, Hicks, Elliott Brothers, and others. All of these are capable of making excellent surveying instruments, though some are noted more for one class and others for another. For watches and chronometers there are Blockley, Dent, Benson, Frodsham, White, and several others who might be mentioned.

PART II.

INSTRUMENTS AND THEIR ADJUSTMENTS.

The Transit Theodolite.

THE best surveying transit theodolites are now fitted with micrometers for reading the angles on the vertical and horizontal circles instead of the ordinary verniers. There are usually four of these—two fitted to each circle—but recently a new pattern has been devised which reduces the necessary number to two. This will be referred to later on, but the first form to be described here will be the micrometer theodolite as generally used on important geographical surveys.

The following is a general description of this instrument with the names of its various parts:—

A is the *Upper* or *Vernier-plate;* it is furnished with two *micrometers*, *a*, 180° apart. B is the *Lower-plate*, graduated into 360°, each degree being again subdivided into 10′, and can, with the micrometers, be read to the nearest 1″ by estimation. These two plates combined are called the *Horizontal limb*, and revolve independently of one another, but when required can be made to move together by tightening the *Clamp-screw* C; the slow motion is obtained by the *Tangent-screw* D; the lower plate has also a *Clamp* E, and a *Tangent-screw* F. G G is the *Tribrach System.* H is the *Horizontal axis.* There are three *Levelling screws*,* I, I, I. K is the *Tripod*, underneath which, in the centre, is a hook (not shown in the drawing) from which to suspend a plummet in order to indicate the exact position where the station peg is to be driven into the ground. L is the clamp screw of the shifting centre, by means of which the whole instrument can be moved slightly

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* Some old theodolites have four levelling screws, but three is the proper number; the fourth is unnecessary and only complicates matters.

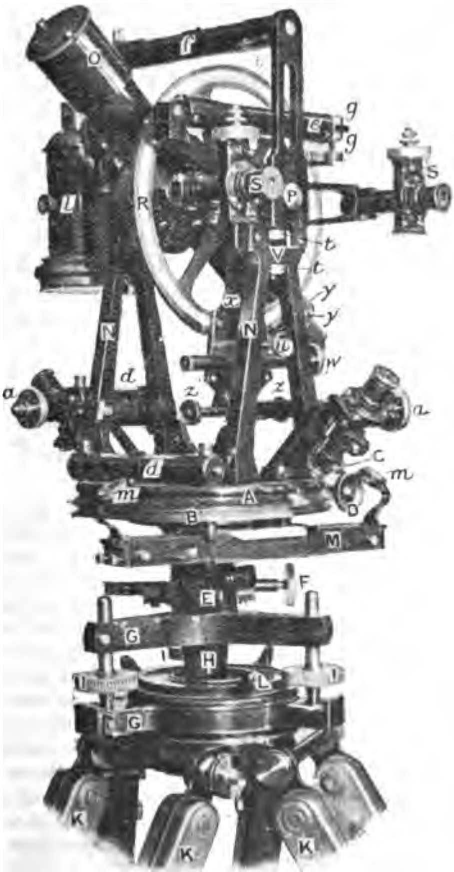


FIG. 1. *Transit Theodolite.*

to enable the plumb-line to be brought exactly over the station mark without moving the legs or disturbing the levels. The lower plate carries a *Trough Compass* M, the needle of which can be accurately set by the magnifiers *m*, and is reversible upon its sapphire centre. The two *Frames* N N carry the *bearings* V for the telescope O, and the graduated circle R, called the *Vertical circle*, with its two micrometers S S. The vertical circle is graduated from 0° to 90° through one quadrant, then again from 90° to 0° in the next quadrant, and so on round the circle; the degrees are subdivided into 10′, and, as is the case with the horizontal circle, can with the micrometers, be read by estimation to the nearest second. Upon the back of the vertical circle, in most instruments, are marked the number of links to be deducted from each chain for various angles of inclination, in order to reduce the distances, as measured along the ground at these angles, to the corresponding horizontal distances. The horizontal axis of the telescope is formed of two cones, the larger ends of which are attached to the telescope tube, while the small ends, called the *Pivots*, *p*, are ground into two perfectly equal cylinders; the pivot which does not carry the vertical limb is pierced, and allows the light of a lamp, *l* *, to fall upon

* As generally supplied by the maker, these lanterns are a constant source of trouble. If there is much wind, it is almost impossible to keep them alight, and even when this has been accomplished, the flickering light they give makes it most difficult to take accurate observations. In practice, except on very calm nights, it is better to dispense with this lantern altogether, and illuminate the wires by means of a conical reflector or a strip of thin white cardboard or thick paper at the object-glass end of the telescope, fastened by an elastic india-rubber band, and bending it over at an angle of about 45° in front of the object-glass, then make an assistant throw the light of a lantern on to the reflecting cone or the strip of cardboard, and the wires will be plainly seen. The intensity of the illumination will be increased or decreased according to the distance at which the lantern is held from the reflector. A piece of copper wire about eighteen inches long, with a small piece of tin soldered to one end, can be used for the same purpose if wound round the object end of the telescope and bent over the object-glass to the required angle; it can be kept in the theodolite box, and is always ready for use. This method of illuminating the wires can be used with a theodolite which has not a hollow axis.

a small reflector (not shown in the drawing), which is screwed into the centre, on the axis of the telescope, and inclined to it at an angle of 45°, by which means the light is thrown directly down the telescope, and illuminates the fine wires, or web, attached to a *Diaphragm* inside the telescope, which is kept in its place and adjusted by the screws *y y*, of which there are four. The *Index-bar*, *x*, is fixed in position by the *Clip-screws*, *z z*. The vertical limb is furnished with a *clamp*, *u*, and a *Tangent-screw*, *w*; *e* is the principal level, fixed to the micrometer or vernier arm, and should be graduated from 0 in the centre towards each end; *d d* are *Levels* at right angles to one another, and *f* is the *striding level*, which is separate from the instrument, for testing the horizontality of the axis of the telescope; *l* and *h* are the small *lantern* and its *holder*, which fits into a slot in the frame on the side opposite to the vertical limb; *g g* are capstan-headed screws for adjusting the level on the vernier arm. The object-glass and eye-piece of the telescope are brought to focus by milled screws (not shown in drawing); a diagonal eye-piece is also supplied with the instrument, and is necessary for astronomical observations of great altitudes; *t t* are capstan-headed screws used in adjusting the axis of the telescope.

The transit theodolite here described is generally packed in two cases for convenience of transport. It is made in two sizes, with circles of 5 inches and 6 inches radius. The instrument of 5-inch size weighs, with its two cases, about 40 lbs., whilst the 6-inch size is about 10 lbs. heavier. The tripod stand, which is separate, weighs about 10 or 12 lbs.

In the ordinary transit theodolite the circles are read by means of verniers instead of micrometers, in which case the verniers should be divided to read to 10″. The vernier theodolite is decidedly lighter and more compact than the ordinary micrometer pattern, but the micrometers are more quickly read than the verniers, especially in a bad light, besides giving closer readings.

A very useful addition to the transit theodolite is a special interchangeable diaphragm fitted with a pair of micrometers, by means of which the distance between the observer and staff of known length can be measured in the manner shown (p. 150).

For geographical work, where the distances are often long, the Indian Survey Subtense Instrument pattern of micrometer is most useful, but

a special diaphragm with two wires fixed at an interval apart to read 1 foot on a staff at 100 feet distance, is sometimes serviceable.

In many old pattern transit theodolites the principal level, instead of being attached to the micrometer or vernier arm, is placed on the telescope. This form is practically useless for the measuring of exact vertical angles, as it is impossible to correct for dislevelment, which is most important (*see* p. 44), for, however accurately the instrument may be levelled at first, it will be found to change slightly during a set of observations. The level on the telescope is perhaps useful for some purposes, but even if one is so fixed the principal level should be attached to the micrometer or vernier arm. The divisions of the level scale should not be more than about 10″ in value, and should be numbered from the centre toward each end.

To Level the Theodolite.—Bring the three levelling screws to about the middle of their runs and level the instrument as near as possible by the legs. Unclamp the upper plate, place it so that one of the levels, *d* (Fig. 1), is in a line with two foot-screws, and bring it to the middle of its run by these two foot-screws, then bring the other level, *d*, at right angles to the first, to a central position by turning the third foot-screw. Instead of the second level the first one only can be used if necessary by levelling it over two screws and then turning the instrument through 90° and levelling it again with the third screw. Next with the *clip-screws alone* bring the long level, *e*, on the micrometer or vernier arm into such a position that both ends of it can be seen when the instrument is turned round in any direction. All this so far is preparatory to the final and accurate levelling which is now effected by the long level, *e*, on the micrometer or vernier arm, as follows:—Place this level, *e*, over two foot-screws, and by these bring it exactly into the middle of its run, noting the divisions at which the level stands when it is central. Next turn the level through 180° (i.e., in the same line as before, but with its ends reversed), and notice how many marks it is out of the central position. Bring it back to the centre of its run *half* by turning the clip-screws *z z*, and half by the two foot-screws used before. Now turn the instrument through 90° (i.e., with the telescope in a line with the horizontal axis and the third levelling screw) and bring the level again exactly to the middle of its run by the third foot-screw. The instrument should now be level in any position.

When the theodolite is furnished with four foot-screws for levelling they must always be used in pairs diagonally opposite to each other.

Adjustments of the Theodolite.

Parallax.—This adjustment consists in bringing the rays of light from the object-glass and the eye-piece to meet at a common focal point on the diaphragm, as in Fig. 2. If the rays do not come to a point at the diaphragm, as is the case in Fig. 3, then the object observed would appear indistinct, and to change its position in relation to the wires as the eye is moved. To effect this adjustment turn the milled-head screw of the eye-piece until the threads of the diaphragm are seen sharply defined against the sky, and then point the telescope at some well-defined

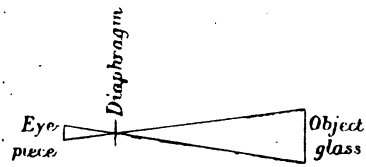


FIG. 2.

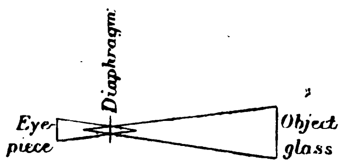


FIG. 3.

distant object, and bring it to the proper focus by the milled-head screw near the object-glass. To test the accuracy of this adjustment, intersect the object accurately by using the tangent-screws, with the centre of the wires in the diaphragm. Now move the head laterally, at the same time watching the intersection of the object with the wires. If the object remains stationary on the wires, parallax has been eliminated; but if it does not, it must be removed by turning the focussing-screws until the object remains stationary in whatever position the head of the observer may be.

Collimation in Azimuth.—A theodolite is said to be collimated in azimuth when the line of collimation, i.e., the imaginary straight line joining the intersection of the wires and the optical centre of the object-glass, cuts the transit axis or axis of vertical motion at right angles. To effect this adjustment level the instrument as carefully as possible, clamp the lower plate, then unclamp the upper plate, and after setting

the A micrometer or vernier at 360°, with the instrument F. L. unclamp the lower plate, and with the two plates clamped together intersect some well-defined distant mark by the *lower* tangent-screw, bringing it on the intersection of the central vertical and horizontal wire. Next unclamp the upper plate, and move it half round (i.e., through 180° or F. R.), turn the telescope over, and again intersect the object, taking the reading on the horizontal circle with the same vernier or micrometer that was reading 360° before. This should now read 180°, and if it does not the instrument is not in adjustment, in which case correct as follows: Take the mean of the reading on the arc and 180°, and set this mean reading on the arc; for example, suppose the reading after turning the instrument through 180°, to be 180° 1′ 40″, then the mean reading between 180° and 180° 1′ 40″ would be 180° 0′ 50″, which would be now set on the arc, instead of 180° 1′ 40″. Looking through the telescope it will now be found that the object is off the central vertical wire. Move the diaphragm to the left or right by its capstan-headed screws *y*, until the central wire covers the object, taking care to loosen one screw before tightening the other. Instead of setting the instrument to 360° first, this adjustment may be made with any reading on the arc to commence with, and, if correct, the difference between the F. L. and F. R. reading will be exactly 180°. However, it saves time and figuring to set it first at 360°. Repeat this operation until the readings taken with the instrument in two different positions, F. R. and F. L., differ from one another by 180°.

The Vertical Adjustment, and the Testing of the Level on the Micrometer or Vernier Arm.—This adjustment combines that for collimation in altitude, and the verification of the level. It is a most important one where altitudes are concerned. With the theodolite in a F. L. position, level it accurately and intersect some well-defined distant object. Take the reading on the vertical circle and write it down, being careful to see that the level is exactly in the centre of its run; if it should not be, make it so by turning the clip-screws. Turn the instrument F. R., intersect the same object; see if the level is still in the centre of its run. If it is not, it must be made so by turning the clip-screws *z z*. With the instrument in this position, again take a vertical reading of the same object, which will usually be a zenith distance, and must be taken rom 90° to obtain the altitude. If the vertical adjustment is correct these

two altitudes, taken F. L. and F. R., will be the same, but usually this is not the case, and the correction has to be made as follows: Take the mean of the two altitudes (F. L. and F. R.), which will be the correct altitude of the object, and set this on the vertical circle. Now, looking through the telescope, bring the object exactly on the intersection of the central vertical and the horizontal wires by the *clip-screws z z*. If the level is in adjustment the bubble will now be in the centre of its run, but when this is not the case it must be placed there by means of the adjusting-screws *g g*. This operation should be repeated until the F. L. and F. R. readings are the same.

Throughout this adjustment it is strictly correct to read both micrometers and take a mean as the result, but when pressed for time it is sufficient to read one micrometer or vernier, care being taken to see that it is the *same* one that is read during the whole operation.

With regard to the clips *z z*, which keep the micrometers or verniers S S in position, never unscrew *both* after the adjustment has been made; but to release the vertical circle before putting the instrument into its box, unscrew only one of the clip-screws, and mark it so that it may be known, and use this *same* screw when setting up the instrument again. The other clip-screw should never be touched; and, indeed, it would be an improvement if one of the clip-screws were fitted with a lock-nut, by which it would be kept in its proper place, and at once be distinguished from the working screw.

To Make the Vertical and Horizontal Wires respectively Vertical and Horizontal.—As these wires are fixed in the diaphragm by the maker so as to cut each other at right angles, it follows that to adjust one wire is to adjust both, and this may be done by the following method:—Level the instrument with care, intersect any small well-defined point with the vertical wire, and see if it continues bisected along the wire when the telescope is moved in a vertical plane. If this is not the case the capstan-headed screws *y y* must be slackened sufficiently to allow the diaphragm to be revolved until this condition is secured, when they must again be tightened. It will now be found that the horizontal wire, if properly fixed by the maker, will continue to bisect an object on which it has been placed when the instrument is turned in azimuth.

In the case of the old pattern theodolite where the level is on the telescope, the vernier of the vertical circle must be clamped at 0° before

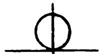
making the vertical adjustment as here described, and kept in that position throughout the operation; but, as previously stated, this form of theodolite should be avoided wherever exact altitudes have to be taken. It is, however, comparatively simple to have a level fitted to the vernier or micrometer arm as recommended, and is not very expensive.

Adjustment of the Horizontal Limb.—After completing the vertical adjustment with the lower plate B clamped, unclamp the upper plate A, and again proceed to level accurately as previously described (p. 32). If the bubble retains its central position whilst the theodolite is turned round horizontally in any direction, it is evident that the internal azimuth axis, about which it turns, is truly vertical. Next clamp the upper plate to the lower plate by turning the clamp-screw C, and loosen the lower clamp-screw E; move the instrument round its azimuthal axis, and if the bubble retains its central position during a complete revolution, the external axis is truly parallel with the internal; when this is not the case, the instrument must be sent to the maker to be remedied.

It is most probable that the levels on the vernier-plate will now be found out of adjustment, and the bubbles must be brought to the middle of their run by turning the capstan-headed screws at the end of each of them.

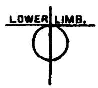
Horizontality of the Rotation Axis of the Telescope.—This is to be tested by the striding-level *f*, which is supplied with the instrument. Place the striding-level on the pivots *p*, and by tapping it gently sideways bring the bubble as near as possible to the middle of its run. When the bubble of the striding-level is steady, read the divisions, and note down the number of the level scale at which one end of it stands. Now reverse the level end for end, read and note the same end of the level as before. If the transit axis is level, the same end of the bubble will read the same on both occasions. If it does not read the same, half the difference is the real error, which can be corrected by the capstan-headed screws *t t* which raise or lower the bearing of the telescope. If there is no striding-level, this adjustment can be tested by observing a long plumb-line, first making the intersection of the threads in the diaphragm coincide with this line, and then, if the point of intersection moves along the line when the telescope is elevated or depressed, the adjustment is perfect; if not, it must be made to do so by turning the capstan-headed screws *t t*.

All first-class instrument makers are very careful, for the sake of their reputation, to see that the theodolite is in perfect adjustment when it leaves their hands, nevertheless it is necessary from time to time to test these adjustments.

When a diagonal eye-piece is used for observing altitudes of the sun, the lower limb has this appearance 

and the upper limb this, 

. When observing altitudes of the sun with the inverting telescope, it must be remembered that what appears to be the lower limb is really the upper, thus: 

and 

. Where the direct telescope is used the reverse is the case.

The Micrometers of the Theodolite.—To Read:—After having made the contact of a star or other object on the central cross wires of the telescope in the usual manner with the tangent screw, look through the microscope of the micrometer and notice the position of the "v"-shaped indicator *a*, which serves the same purpose as the

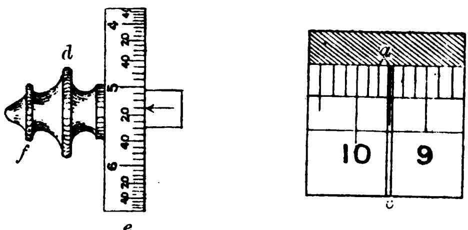


FIG. 4.

arrow on a vernier. In the case shown (Fig. 4) it is clear that the reading is somewhere between 9° 30′ and 9° 40′. Next turn the milled head-screw, *d*, attached to the micrometer drum, *e*, until the two fine wires, *c*, are made to exactly include the ten minutes' division of the

arc scale preceding the indicator, a (i.e., the division reading next *less* than the indicator, a), which in this case would be 9° 30′. Now read the minutes and seconds on the drum of the micrometer, which, added to the 9° 30′, give the reading required. The complete reading in this case would be 90° 35′ 15″. The micrometer is so arranged that one complete turn of the drum equals 10′, or in passing the wires, c, from one ten minutes' mark on the scales to another, the drum is turned exactly once round.

To Adjust the Micrometer:—When the "v" shaped indicator, a, is exactly opposite a whole degree or ten minutes mark, and the wires are made to include this mark, the reading on the drum should be 0. See if this is the case, and if not, make the drum read 0 by unclamping the screw, f, which clamps the drum, and turn the drum, being careful to clamp it firmly again after the adjustment has been made. It is perhaps as well for the B micrometer to read a few seconds more than the A.

Sometimes the indicators themselves are found to be out of adjustment. To test this set the indicator of the A micrometer to a whole degree mark on the arc, and then see if that of the B micrometer reads a whole degree, or a difference of exactly 180°. If it does not it must be made to by the small screw arranged for the purpose under the micrometer. Before moving this screw it is necessary to slacken the screws fastening the eye-piece and the part of the micrometer carrying the indicator, a, to the rest of the instrument.

To read the Vernier of a Theodolite or Sextant.—It will be seen by examining the arc of a vernier theodolite or sextant, that 60 divisions of the vernier just cover or coincide with 59 divisions on the arc; or the difference between a division on the arc and one on the vernier is $\frac{1}{60}$ of a

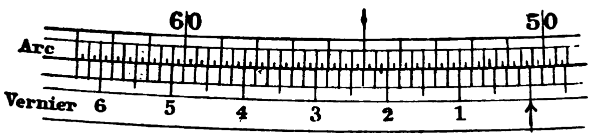


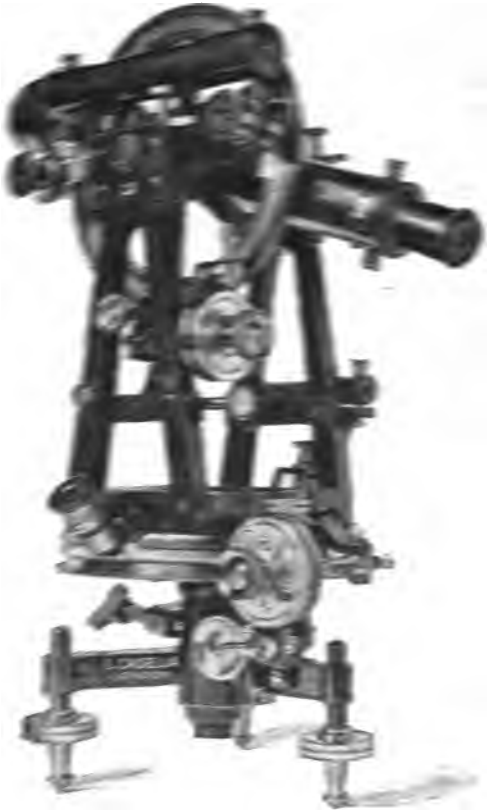
Fig. 5.

division of the arc; if, therefore, a division on the arc is 10′, the difference in question will be $\frac{1}{60}$ of 10′, or 10″. Suppose, now, that the index, or arrow, stands between the second and third divisions on the arc, beyond the 50°, and that, by carrying the eye along the vernier, it is found that

the coincidence of the two lines takes place at the fourth line to the left of the line on the vernier marked 5 (Fig. 5), then the value of the space to be determined will be 5′ 40″, every sixth division on the vernier marked with a longer line representing one minute. The magnitude of the whole angle is therefore 50° 20′ + 5′ 40″, or 50° 25′ 40″. This supposes the theodolite or sextant to read to the nearest 10″. Some instruments are graduated to read to 15″, 20″ or 30″; but the same method of reading off is to be followed as above. On the arc of a sextant the divisions are continued to the right of 0° or zero, for the purpose of finding Index Error by the Sun. In this case the arc is read off exactly as before, with the exception that it must be supposed that the vernier is numbered in the reverse direction, i.e., the 10′ on the vernier must be taken as 0°, 9′ as 1′, 8′ as 2′, 7′ as 3′, and so on.

Reeves's Tangent-Micrometer for Theodolites.—A new pattern micrometer for reading the circles of the theodolite with greater accuracy than with the ordinary vernier has lately been devised, and is called the Tangent-Micrometer. This has decided advantages, inasmuch as it greatly reduces the bulk of the instrument, so that instead of the necessity of having to pack it in two cases, it can easily be carried in one; besides which there is far less liability of its being put out of adjustment. It consists in making use of a carefully constructed tangent-screw, as the micrometer, combined with a special arrangement for reading. The following is a short description:—*a* (Fig. 6) is a clamp-screw of the ordinary pattern, and *b* the usual tangent-screw, turned by the milled head *e*, for making the exact contact of an object on the intersection of the cross-hairs in the telescope. The tangent-screw *b*, which is specially constructed, carries the pointer *d* and the micrometer drum, the central part *k* of which, with the pointer *d*, is rigidly attached to the tangent-screw. The outer rim or dial *c*, upon which are engraved the numbers representing single minutes and tens or fives of seconds of arc, also carried by the tangent-screw, is separate, and only attached to the central part *k* by a spiral spring inside the drum. By means of this spring the outer rim or dial *c* is, in its normal position, kept with the 0 or zero opposite the pointer *d*, which is effected by the stop *s*, attached to the dial *c*, being pressed by the spring against the pointer *d*. *g* is a clamp actuated by the lever *f*, by means of which the dial *c* can be firmly held in any position; in which case, when the

[illegible]



[illegible] Theodolite with [illegible] Micrometer.
[illegible] by the spiral spring, returns to [illegible] opposite the pointer.

Instead of a vernier, the upper plate carries a fine pointer, *i*, which serves as an indicator as in the ordinary theodolite micrometer. There are two of these indicators, 180° apart, whilst *h* is a reading microscope for setting the indicators.

The differences of the measures of the tangents between any two intervals of ten minutes of arc for the degree or two represented by the run of the tangent-screw from its centre to either end of its run are practically equal, specially as the micrometer drum is divided for a position midway between the centre and end of the run.

To use the tangent micrometer: When *g* is unclamped, the pointer *d* remains at 0, the tangent screw, dial, and pointer all turn together, and the screw acts exactly as an ordinary tangent-screw. Therefore, with the clamp *g* released, make the contact of a star or terrestrial object in the ordinary manner, adjusting finally with the tangent-screw. To take the reading, first clamp the dial, and looking through the reading-glass *h*, it will be seen that the indicator *i* is somewhere between two marks on the arc. Now turn the milled head *e* of the tangent-screw in the direction shown by the arrow, until, looking through the reading-glass *h*, the indicator *i* exactly coincides with the preceding 10′ or 20′ mark, or the mark next less in reading than the position in which it stood when the contact of the object was made.

The complete reading will then be the reading on the arc, plus the minutes and seconds of arc on the micrometer drum as shown by the pointer *d*. Both "A" and "B" readings can be taken with the same micrometer; for having taken the "A" reading as shown here, look through the other microscope, and take the "B" reading in exactly the same manner.

Any reading can be set upon the arc by reversing the above operation. To do this, first set the indicator *i* to the preceding mark on the arc, then turn the *drum* of the micrometer *only* until the pointer *d* indicates the required odd minutes and seconds. When this is done, clamp the drum of the micrometer and turn the tangent-screw in the opposite direction to that for ordinary reading, until the pointer *d* is at 0° on the micrometer drum.

The figure shows the micrometer fitted to both the horizontal and vertical circles of a 4-inch transit theodolite.

This micrometer is made only by Casella, 11, 13, 15, Rochester Row, S.W., and can be fitted to any ordinary theodolite.

Measuring Angles with a Theodolite.—All angles measured with a theodolite, whether horizontal or vertical, should be taken in pairs, with the face of the vertical circle to the left of the observer, or "face left" (F. L.) as it is called, and then with the face of the circle to the right or "face right" (F. R.). The mean of the two readings should be considered as correct. In the case of altitudes, as a rule the F. R. reading gives the zenith distance of the object and must be subtracted from 90° to obtain the altitude. For depressions the opposite is the case. The micrometers or verniers of the vertical and horizontal circles should be lettered. The readings of the level scale are most important and should be carefully noted *immediately after making the contact.* They are called E and O readings, the E reading being that of the end of the level nearest to the eye at the time of the observation, and the O that nearest the object glass. The method of finding the value in arc of one division of the level scale, and of applying a correction to the altitudes for dislevelment, is shown on p. 43. An example of the form for recording the horizontal and vertical angles between two terrestrial objects, with the level readings, is as follows:—

			Horizontal Angle.	E.	O.		Vertical Angle.
			° ′ ″				° ′ ″
One pair	F. L.	A				C	
		B				D	
	F. R.	A				C	
		B				D	

When great accuracy is required, the reading of the horizontal angle between two objects should be repeated several times in different parts of the circle, using different zeros, and the mean taken as the correct angle. This will tend to correct for graduation errors of the instrument. It is also advisable that the F. L. readings should be taken to all the objects, moving the telescope round from left to right; and then all the F. R. readings to the same objects, moving the telescope round from right to left.

To obtain the Value of one division of the Level Scale.—The method of ascertaining the value of one division of the level scale, and of applying the correction for dislevelment to the vertical angles, is as follows:—

By means of the clip screws move the bubble up to one end of its run, say towards the object end, so that the object end of the bubble corresponds approximately with the extreme reading of the scale. Intersect with the horizontal wire some convenient object for observing. Read and record one end of the bubble, say the object end, and the vertical angle. Now, by means of the clip screws, bring the bubble back towards the eye end as far as possible, taking care that it is really floating, and within the graduations of the scale. Reintersect the same object as before, and record the vertical angle and the reading of the object end of the bubble in its new position. The difference between the two readings on the arc brought to seconds, divided by the difference of the two readings of the object end of the bubble, gives the value of one division of the level in seconds of arc.

Thus :—

	Elevation.			Object end of bubble.
1st observation . . .	7°	3	$28''$	18 divisions
2nd „	7	0	0	6
Difference . . .	0	3	28	12

$$\text{Value of one division} = \frac{208''}{12} = 17''\cdot 3.$$

This operation must be repeated several times in order to get a good mean value. The bubble of a level is very susceptible to changes of temperature (cold makes it lengthen and heat contracts it), so care must be taken that it is not exposed to such changes while this operation is being performed. Should there be any chance of the bubble altering its length while determining the value of a division of the scale, it will be necessary to read and record both ends of the bubble.

To apply Level Correction to Theodolite Vertical Angles.—In observing, as described previously, for each vertical angle, the readings of both ends of the bubble must be recorded. To apply the correction the rule is as follows :—

Divide the difference between the sums of the readings of the object end (O.) and eye end (E.) by the total number of readings, and the result will be the dislevelment in terms of divisions of the scale. Multiply this result by the angular value of one division of the scale found as above, and the result is the angular correction for dislevelment to be applied to the

mean vertical angle. Supposing two observations are taken to a point, one face left and one face right, and the level readings are as follows :—

	O.	E.
F. L. . .	5	8
F. R. . .	7	6
	12	14

In this case the sum of the readings of the eye end exceeds that of the object end by two. The number of readings of ends of the bubble is four. So to get the dislevelment in terms of division of the scale we must divide 2 by 4 = 0·5. Suppose the value of one division of the level scale to be 17·3 seconds, then to get the correction we must multiply 0·5 by 17″·3 = 8·7 seconds. The eight seconds of arc must be applied to the mean of the two observed angles. With regard to its sign, the eye end being in excess, the correction must be subtracted from an elevation and added to a depression. If the object end were in excess, the process would, of course, be reversed.

$$\text{Correction to altitude} = \frac{\text{O.} - \text{E.}}{\text{number of readings}} \times \text{value of 1 division.}$$

The Sextant.

The principle on which the sextant is constructed is that the angle between the first and last directions of a ray which has suffered two reflections in one plane is equal to twice the inclination of the reflecting surfaces to each other.* The arc on which the angle is measured must therefore be divided into double the number of degrees which properly belong to an arc of the same extent. With this instrument we can

* This will be clear from the following:—Suppose two systems of parallel rays, each parallel to the plane of the paper, the one in the direction of A B, the other in that of *a b*. Let rays of the system parallel to *a b* fall upon a plane reflecting surface *b*, this surface being at right angles with the plane of the paper. Let *b p* in the plane of the paper be perpendicular to this reflecting surface; then the ray *a b* will, after reflexion, follow the direction *b* B in the plane of the paper, the angle *p b* B being equal to the angle *a b p*. Let this reflected ray fall upon a second plane reflecting surface B, this

measure the angle between two objects, in whatever direction they may be placed, provided the angle is within its limits.

With the aid of the following figure (Fig. 8), the different parts of the sextant, with their names, may be distinguished :—

A is a plane mirror called the *index glass;* it is set in a frame, and is fixed on a centre perpendicular to the plane of the instrument; it moves with the *index bar* B C, the end of which, C, slides over the *arc* E F, which is graduated (on an inlaid plate of platinum or silver) from 0° to about 140°; each of these degrees, according to the radius of the

---

surface likewise being at right angles with the plane of the paper, and B P perpendicular to it. The second reflexion will be in the direction B E, B E being in the plane of the paper, and the angle P B E equal to the angle b B P; and the eye, being at E, will receive the ray and refer it to the direction A B E. Consequently, if at the same time the direct ray A B fall upon the eye, the objects from which the systems of rays parallel to $a\,b$, A B, respectively emanate will appear to coincide.

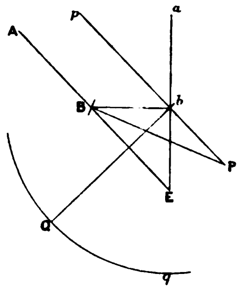


FIG. 7.

Now it will be obvious that if the mirror b be made to revolve upon an axis at right angles to the plane of the paper, the original direction $a\,b$ of the ray which, after two reflexions, is seen to coincide with the direct ray, will vary; in other words, the angle between the original directions of the two rays and that between the surfaces of the mirrors are dependent one on the other. To determine the connection between them, produce A B, $a\,b$ to meet in E, and $p\,b$, B P to meet in P. Then—

angle between mirrors = angle between the normals to them = $\angle\, b\,\mathrm{P}\,\mathrm{B}$,
and angle between the rays = $\angle\,\mathrm{B}\,\mathrm{E}\,b$;

$$\text{and } \therefore \angle\, a\,b\,\mathrm{B} = 2\,\angle\, p\,b\,\mathrm{B}, \text{ and } \angle\, b\,\mathrm{B}\,\mathrm{E} = 2\,\angle\, b\,\mathrm{B}\,\mathrm{P},$$

$$\therefore \angle\, a\,b\,\mathrm{B} - \angle\, b\,\mathrm{B}\,\mathrm{E} = 2\,(\angle\, p\,b\,\mathrm{B} - \angle\, b\,\mathrm{B}\,\mathrm{P}).$$

$$\left.\begin{array}{ll}\text{But} & \angle\, a\,b\,\mathrm{B} - \angle\, b\,\mathrm{B}\,\mathrm{E} = \angle\,\mathrm{B}\,\mathrm{E}\,b \\ \text{and} & \angle\, p\,b\,\mathrm{B} - \angle\, b\,\mathrm{B}\,\mathrm{P} = \angle\, b\,\mathrm{P}\,\mathrm{B}\end{array}\right\}\begin{array}{l}\text{because the exterior angle of a}\\ \text{triangle is equal to the sum of}\\ \text{the interior and opposite angles;}\end{array}$$

$$\therefore \angle\,\mathrm{B}\,\mathrm{E}\,b = 2\,\angle\, b\,\mathrm{P}\,\mathrm{B};$$

or the angle between the original directions of the rays is the double of that between the mirrors.

instrument, is divided into 10′ or 20′, and these are subdivided by the *vernier* D into 10″ or 20″; these divisions on the arc are continued a short distance on the other side of zero (0°) towards F, forming what is termed the arc of excess. The index is secured to the arc by a *clamp screw* G, which must be released when the index has to be moved over

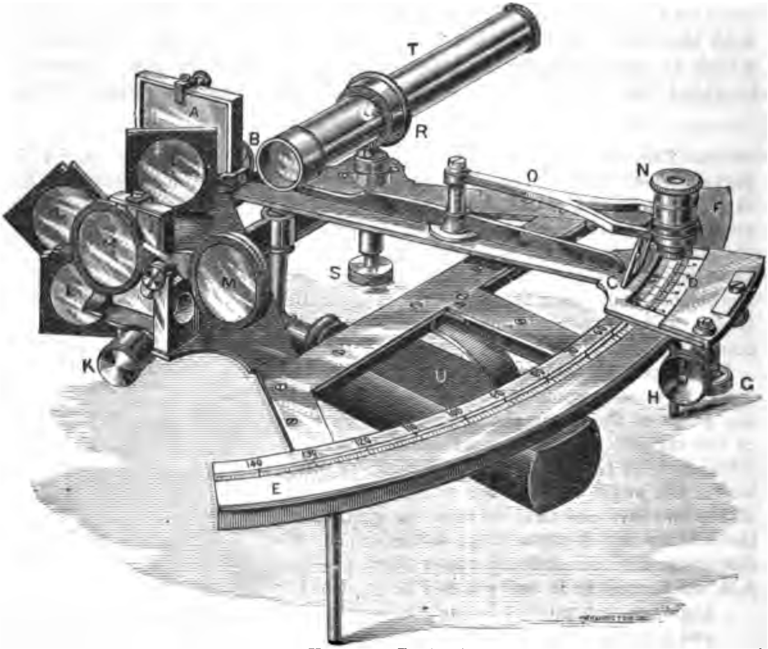


FIG. 8.—*Sextant.*

a large portion of the arc. In order to obtain the slow motion necessary for the accurate measurement of an angle, a *tangent screw*, H, is fixed to the index, but does not act until the index is fastened by the clamp screw G.

I is a fixed plane glass, the lower half of which, next to the frame of the instrument, is silvered, and the upper half left clear. It is called

the *horizon glass*, and must be perpendicular to the plane of the instrument, in such a position that its plane shall be parallel to the plane of the index glass when the index points to zero (0^c) on the arc; it is adjusted by means of the screw K.*

L and M are coloured glasses of different depths of shade, any one of which can be turned down in front of either the index or horizon glass to moderate the intensity of the light before reaching the eye, when a bright object, such as the sun, is observed. N is a *microscope* which is carried on a moveable arm O, and can be adjusted to read the divisions on the graduated arc and vernier. T is the *telescope*, which should be fastened into its collar, by means of a split thread, and not be screwed in, which takes longer. At the eye end of the telescope coloured shades can be attached which should always be used when observing the sun in an artificial horizon in preference to the shades L. M. The telescope is carried by a double ring, so constructed that it furnishes means of adjusting the line of collimation: this ring is attached to a stem S, which can be raised or lowered until objects seen by reflection, and directly, appear of the same brightness. U is the handle, which is often fitted with a brass centre, having a hole in it, to admit of its being fastened to a stand.

Reeves's Automatic Clamp and Endless Tangent Screw for Sextants.

A spring clamp and tangent screw, with an endless thread, has recently been devised by Mr. E. A. Reeves, and can be obtained from Messrs. Cary, Porter & Co., 7 Pall Mall, S.W. This is shown on p. 48.

A is the section of the back view of an arc of a sextant; B the tangent screw upon which the endless thread D has been cut; C is a lever which, when pressed by the forefinger in the direction of the arrow, raises the screw D from the arc A by means of the cam arrangement F, in which case the vernier arm G can be moved freely to any position on the arc, and the approximate contact made in the ordinary manner. When this is done, by releasing the lever C, the screw D, actuated by the spring H, is pressed hard against the arc and automatically clamps the vernier

* The form and position of this screw differs very much in different sextants; in many, the adjustment is made by two small screws bearing on the back of the glass.

arm G. The accurate contact is now made by turning the tangent screw B with the endless thread D, which causes the vernier arm to move slowly along the arc, as far as required, without the possibility of the

FIG. 9.—*Reeves's Automatic Clamp and Endless Tangent Screw.*

screw coming to an end. This endless tangent screw is made only by Cary, Porter & Co., and can be fitted to any sextant at little cost.

Adjustments of the Sextant.—The principal are the following :—

1. To make the index glass perpendicular to the plane of the instrument.
2. To make the horizon glass perpendicular to the plane of the instrument, and parallel to the index glass when the index points to zero (0°) on the arc.
3. To make the axis of the telescope parallel to the plane of the instrument, in which the index moves.

1*st Adjustment.*—This adjustment rests with the maker; and being once made cannot be deranged, except by a fall or blow, against which every precaution must be taken. The instrument should, however, be occasionally verified by the observer in the following manner:—Set the index at about 60°; and, holding the sextant in the left hand, with the right move the index gently backwards and forwards, looking, at the same time, obliquely into the index glass; then, if the image of the arc in the

mirror appears in perfect continuation of the arc itself, the adjustment is perfect; when this is not the case, the index glass is out of adjustment. If the derangement is great, the sextant is for the time being useless; if small, it may be remedied by means of certain screws fitted at the back of the glass.

2nd *Adjustment.*—Having screwed in the telescope, look through it and the horizon glass at the sun, or, still better, a star, and move the index backwards and forwards, on each side of zero (0°), when the reflected image of the object ought to pass exactly over the object itself. If it does not do this, but passes either to the right or left of it, the horizon glass is out of adjustment, and its adjusting screw must be gently turned until the reflected image does pass directly over the object itself.

3rd *Adjustment.*—Screw the telescope firmly into the collar, turn the eye-piece until two of the wires in the focus of the telescope are parallel to the plane of the instrument. Select two stars, not less distant from each other than 90°, bring them into exact contact on the wire nearest to the plane of the instrument; fix the index, and move the instrument so as to throw the images upon the upper wire; if the contact remains perfect the adjustment is perfect: if not, it must be rectified by the two opposing screws in the double collar, taking care to slacken one before tightening the other: the one to slacken is that on the side towards which the contact opens.

Index Error.—When the index is set at zero (0°) on the arc, the horizon and index glasses should be parallel, and the two images of a distant object, as a star, should exactly coincide; when this is not the case, it may be remedied by turning a screw in the mounting of the horizon glass. If this adjustment is not made, there will be an error in the place of the *beginning* of the graduation; this is called the Index Error; its amount is easily determined, and, as it affects all angles alike, it is usual to admit the existence of this source of error, and apply correction for it, in preference to making the adjustment, specially as it varies with change of temperature. For this reason the index error should always be determined when observing with a sextant.

To find the Index Error by a Star.—Set the index at zero (0°), screw in the telescope, and, with the tangent screw, make the two images of a star, as seen through the telescope, coincide; then the reading on the arc

will be the index error, subtractive when the reading is to the left of zero, additive when to the right.

By the Sun.—Clamp the index at about 30′ to the left of zero, and looking through the telescope at the sun, the images will be seen nearly in contact; make this contact perfect with the tangent-screw, take the reading, and call this "on the arc"; next, set the index, at about 30′ to the right of zero, and make the contact of the two images perfect as before, take the reading, and call it "off the arc": half the difference of these two readings is the Index Error.

Examples.

(1)

	′	″
On the arc	33	10
Off the arc	29	30
2)	3	40
Index corr. *subtract* =	1	50

(2)

	′	″
On the arc	29	30
Off the arc	33	10
2)	3	40
Index corr. *add* =	1	50

As a check on this observation, for inexperienced observers, it may be noted that one-fourth of the sum of the readings on and off the arc ought to be the sun's semi-diameter, as given in the 'Nautical Almanac.' When the index error is determined by the sun, the shade on the eye-piece of the telescope with which the final contact of the altitudes is to be made, should be used.

Centering Error.—In addition to the foregoing, every sextant is liable to errors caused by:—

1. The centre of the pivot of the index-bar carrying the vernier not being identical with the centre of the arc.
2. Imperfect graduation of the arc.
3. Flexure of the whole instrument caused by irregular expansion under the heat of the sun.
4. Shocks or blows which may cause bending of parts of the frame or of the index-bar, and thus cause eccentricity between the vernier and arc.

These errors are generally included in the term "centering error."

The original error included in [1] and [2] can be determined at the National Physical Laboratory, where apparatus for the purpose is established. Those under [3] and [4] are manifestly variable.

In a good sextant the original error should be small, amounting only to a few seconds, but instruments are made which have much larger errors, and as these are enormously multiplied in their effect in some observations, a traveller should always have this error determined before leaving England.

The Artificial Horizon.

The artificial horizon is a reflector, the surface of which is perfectly horizontal; it is used in combination with the sextant for observing altitudes. Though the principle of all is the same, there are several forms of this instrument, the most common, as well as the best, being a small shallow trough, containing pure, clean mercury,* which reflects the image of a celestial body. This is protected from the disturbing effects of the air by a roof, for convenience made to fold, the two sloping sides of which are made of glass plates accurately ground to true planes: these must be carefully examined to see that they are of uniform thickness and density. Should the traveller have the misfortune to break one of his glasses, and replace it by one not tested, he must be careful to reverse the roof between two observations, or once in a set. Captain George's horizon, in which a glass plate floats on the surface of the mercury, is in some respects more convenient; but it is more liable to errors arising from any disturbance communicated to the mercury by wind. Casella makes a very portable form of mercurial artificial horizon.

Another form of artificial horizon is the black plate. It generally consists of a plane of black plate-glass set in a metal frame, and levelled by a bubble. This form answers fairly well in the day-time, when the

* The best method of cleaning the mercury is to pass it several times through a funnel of rough paper, the aperture through which it runs being very small, but if the mercury is not pure it gives an imperfect reflection, and its level is apt to be untrue. The quicksilver of commerce is generally mixed with lead, bismuth and zinc, which have to be dissolved out of it by nitric acid; it may, however, in case of emergency, be rendered serviceable by shaking it for some considerable time in a bottle with a little powdered sugar, or even sand, and afterwards straining it through a piece of fine linen or chamois leather, but it is a troublesome and not very satisfactory process.

sun is the object observed, but at night there is so much loss of light with the black plate that it becomes extremely difficult to use in star observations. In order to overcome this difficulty, artificial horizons of this class have been constructed, with a brass frame, containing a black plate on one side, for day observations, and a silvered mirror on the other, for night. To the frame are attached fixed levels, by which it can be brought to a true horizontal position. It is however preferable to have separate levels to stand upon the glass plate, so that their ends can be reversed. This is a very portable instrument, but its use can only be recommended in the absence of a mercurial artificial horizon, and when the glass used in its composition has been ground into a true plane, and tested at the National Physical Laboratory in the same manner as a sextant index-glass. Every care must be taken to level this instrument accurately, or the observations taken by means of it will be of little value. Any form of artificial horizon that is used should be kept clean and free from dust.

Should the artificial horizon be broken or lost, a substitute may be formed by treacle or other viscous liquid, or even, in calm weather, by water, in a tray or basin.

Sextant-Stand.

Though sextant-stands vary considerably in the manner in which they are constructed, the object in all cases is the same, viz.:—to provide a means by which the sextant can be fixed in any position convenient to the observer, and also to give that steadiness, so important in sextant observations, which is often wanting in the traveller's hand after a hard day's journey, or an attack of fever. Cary, 7, Pall Mall, has succeeded in making a very convenient form, and one that is in many respects superior to the old form. The only adjustments are to place the stand as level as possible, and in such a position that the plane of the sextant shall be in the plane of observation.

Watches.

The keyless half-chronometer is the most suitable watch for a traveller in unexplored countries. (The half-chronometer watch is an English lever watch, with compensation balance, and a carefully-tempered balance spring.)

The ordinary pocket chronometer is not calculated to stand the rough usage to which most travellers' watches are subjected. The objections to it are: (1) The extreme delicacy of the escapement and liability to injury from rust or accident. (2) Its great liability to stoppage from various causes, such as a sudden jerk when riding or travelling over a rough country; even if in the act of winding it the holder should inadvertently give a circular motion to his hand in a direction opposite to that in which the balance-wheel is moving at the same instant, it may stop. (When a chronometer is once stopped it will not start again unless a circular motion be given to it.) (3) The impossibility of its repair when injured, except by highly-skilled workmen, and when very slightly injured, the consequent great disturbance and irregularity in its rate. Box chronometers may be taken upon river expeditions when they can be kept on board the boat, but they are unsuitable for rough land journeys.

Under favourable circumstances, and in skilled hands, pocket chronometers have done good service, but this is exceptional. The price of a good pocket chronometer, in a silver case, is about £45.

Half-chronometers are not liable to stop from the before-mentioned causes, and they are more easily repaired. They may be carried in the pocket under conditions of rough usage, short of actual violence, and under ordinary circumstances their performances are frequently but little inferior to those of a chronometer at rest.

Of late years, great improvements have been made in the manufacture of the lever escapement, compensation balances, and the balance springs, upon which the ability of a watch to keep a steady rate in a great measure depends. The keyless mechanism has also been perfected, and it is not necessary to open the case of a keyless watch in order to wind it; thus the works receive increased security from dust and damp, the two great enemies of all time-pieces.

The following is the description of such a watch as would be best suited to a traveller. The watch should be an 18-size half-chronometer; the bezel (or frame which holds the glass) should have neither hinge nor spring, but should fit very closely over the watch-case, and screw on, as is the case with the watches supplied to travellers by this Society. Great care should be taken to see that the marking of the minutes on the dial is correct, so that in whatever part of the hour circle the minute hand

shall point to a division, the seconds hand shall at the same time point to 0. This perfect coincidence for the whole circle of the dial is by no means common; its absence is chiefly due to the great difficulty of getting the dial painters to divide every minute division exactly to a second as marked in the seconds dial, and the error is often so great as to be a cause of annoyance to the traveller, who will have frequent difficulty in deciding as to which minute the seconds belong. The seconds dial-plate should be sunk, and the glass should be thick flat crystal. The cost of a good watch of this description varies from £30–£40, according as to whether it is a going-barrel or fusee. The latter is preferable, as it is certain that the fusee watch will keep an exact proportion of its daily rate throughout the twenty-four hours, and it is also fitted with an up and down dial, showing when the watch was last wound, and when it will require winding. Both "fusee" and "going-barrel" watches for observation purposes should be "free sprung," as a much steadier rate is obtained therewith.

The keyless watch has many advantages over the old form, of which the following are some:—It cannot be wound the wrong way. It cannot be overwound, and the case has not to be opened for winding. When the glass and back are made to screw on, as made by Blockley, Duke Street, St. James's, or Benson, Ludgate Hill, and the winding-button is fitted with a screw cap, a watch of this kind has been placed in water, and proved impervious to damp after several hours' immersion. Should the winding mechanism get out of order, the watch can be wound with a common key in the same manner as an ordinary watch.

Care should be taken to wind a watch at about the same hour every day, and as nearly as possible to subject it to the same daily treatment with regard to its position in the pocket, or the place where it is laid down at night.

In purchasing a watch, be sure to go direct to the manufacturers, and make them responsible for it.

Cheaper watches, *purporting* to have compensation balances, and the best balance springs, may be obtained from many shops; but it will often be found (when too late to replace them) that they are not all they profess to be, that they have never been properly adjusted, and are, in consequence, so affected by change of position and temperature as to be useless for scientific purposes.

Persons not having much experience with watches frequently expect too much from them, and are under the impression that if a watch maintains a good rate in England, this rate will remain unchanged in the tropics, where the heat is great. This is not the case, as the rates of all watches, no matter how carefully compensated they may have been, will undergo a change if subjected to great variations of temperature, and it is absolutely necessary that frequent observations should be taken for determining the rate of the watch under these altered circumstances by one of the methods given, pp. 228–237. It must also be remembered that if a watch is allowed to run down, it will probably take quite a different rate when again set going, and that the rate of a watch when lying down almost always differs slightly from what it is when carried, hence the necessity for the traveller to take the time of his observations for error and rate, while carrying the watch in the same manner he intends to do during his journey.

The Plane Table.

The plane table is, in substance, a drawing board fixed on a tripod, so that lines may be drawn on it by a ruler placed so as to point to any object in sight. Its advantage is, that it enables a survey to be made without the aid of, and in less time than with other instruments. It is specially useful for filling in the topographical features and details of a survey between trigonometrically fixed points.

Though the principle on which all plane tables are constructed is the same, they vary considerably in detail. Those, for instance, used by the United States Coast Survey, and several of the European Governments, are very elaborate instruments, fitted with parallel plates and levelling screws, having also a telescope in the place of the ordinary sights.

The Table.—A (Fig. 10) is a rectangular board of well-seasoned wood, and can, within certain limits, be made of any size to suit the work intended to be done. To this board the paper to be drawn on may be attached either by drawing-pins, clamping-plates, or a box-wood frame, E, which is occasionally graduated in the same manner as a protractor, and can be used to measure horizontal angles, when the fiducial edge of the ruler is placed against a pin in a small hole, in a brass plate in the centre of the table, which is provided for the purpose. A stud, on the under part of the

Fig. 10.

table, fits into a socket in the *tripod*, F; the table can then be revolved to any horizontal position, and there fixed by tightening the large *nut*, G, on the clamping-screw attached to the stud.

The Tripod, F, should be a split one, and for convenience of packing the legs should telescope. This arrangement is also convenient for setting up the instrument on sloping ground. The screws for tightening the tripod legs should be enlarged at the end so as to prevent their falling out. At times it will be convenient to have the plane-table tripod made so that it can be used for other instruments as well.

The Alidade, B, is a flat ruler, having a fiducial edge, each end of which carries a sight-vane. Upon the ruler should be engraved a diagonal scale of inches, reading to hundredths of an inch, and another giving miles or yards corresponding to suitable natural scales, or R. F., say, 1:125,000 and 1:250,000. In the sight-vane, three or four small holes should be drilled at intervals, as it is often very difficult to see objects through the slit. On the centre of the ruler is a small *circular level*, C, to be used in setting up the table. When no telescope is fitted to the alidade, in mountainous countries the elevation or depression of an object to be intersected is often more than can be embraced by the sights, in which case the intersection must be effected with the assistance of a plummet suspended in the exact ray, either before the object sight or behind the eye-sight as may be required.

The Compass, D, should have a needle about four inches long, contained in a rectangular metal box, and is so arranged that when the needle points to north it will be parallel to the outer straight edge of the box.

A pair of compasses, paper, india-rubber, pencils, a pen-knife, and some pins, complete the essentials for plane-table work; the latter, however, can be dispensed with with advantage by an experienced surveyor.

The plane-table here described is simple, and very light forms in this pattern are made for mountain work, as well as the larger and heavier forms.

Without attempting too much elaboration, which is a mistake, for after all the plane-table can never take the place of a good theodolite, it is a great advantage to have a simple telescope with cross-wires, fitted to the ruler, instead of the ordinary alidade. Distant points can then be much more readily distinguished, and objects of any altitude can be readily intersected. A telescope of this kind, made to *fold* on to the

ruler and packed into a flat case, has been designed by Mr. E. A. Reeves, and is here shown (Fig. 11). It is compact and light, and occupies little

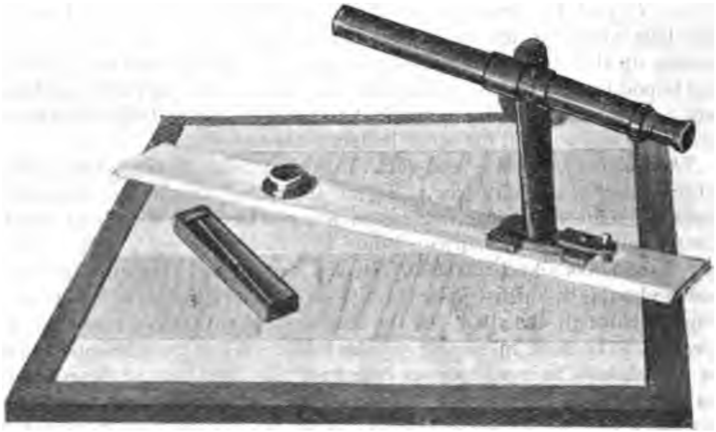


Fig. 11

space in a case. A clamp and tangent-screw is also fitted to the plane-table head, which are convenient for purposes of exact intersection.

It is not considered necessary, in these 'Hints,' to give any detailed description of the more elaborate forms of the plane-table, but any person desiring information on the subject can obtain it by applying to the Instructor at the Society's rooms. (*For instructions for using this instrument in the field, see pp.* 124–141.)

Subtense Instrument and Tacheometer.

A Tacheometer is an instrument for measuring small angles. Of the many different types of tacheometer in use by surveyors the form adopted by the Indian Government, and made by Messrs. Troughton & Simms, is best suited to meet the requirements of the traveller. This form is known as the *Indian Survey Subtense Instrument*, and consists of a *telescope* A, fitted with a pair of *micrometers*, B B, which are used

for measuring either vertical or horizontal angles, as they can be turned through an angle of 90°, and fixed in that position by the *screw* C. The telescope is mounted on *standards* D D, over a *prismatic compass* E, and is furnished with a *small circle*, F, for taking vertical angles, which

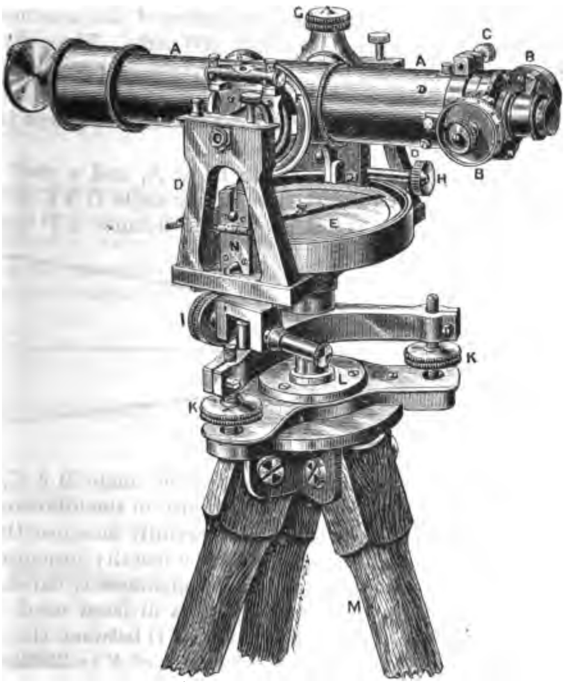


FIG. 12.—*Subtense Instrument.*

can be read to minutes. G is the screw by which it is clamped in altitude; H is the *vertical slow motion screw.* The instrument is fitted with a screw (not shown in the plate) for clamping it horizontally, and I is the *horizontal slow motion screw.* The magnetic bearing of any object is

read through the *prism* N. There are three *levelling screws*, K, which fit into a *tribrach* L, that screws on a *tripod* M. The instrument is levelled by means of the screws K, and a level attached to one of the standards (not shown in the plate).

There is a disc of glass visible in the field of view, divided in such a manner that each division equals one revolution of the micrometer head, and each micrometer head is divided into 100 parts. These divisions are both vertical and horizontal, to suit the corresponding positions in which the micrometers are used.

The measurement of distances by means of this instrument is based on the solution of a triangle.

In Fig. 13, suppose the instrument to be at A, and a staff of known length to be represented by B C; then if the angle B A C is measured, and the length of the staff B C is known, the distance A D can be easily

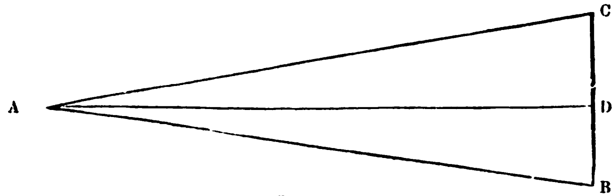


FIG. 13.

computed. In order, however, to measure the angle B A C, the value of the micrometer divisions must be determined in the following manner:—Set the telescope to *solar focus*, and carefully measure the distance A D from the instrument to a staff of known length; measure the angle B A C subtended by the staff with each micrometer, carefully noting the number of divisions and decimals of a division used with each. Divide the length of the rod by the distance A D between the instrument and the rod, and multiply this by the cosecant of $1''(=206265)$, and the result will be the value of the angle B A C in *seconds* as measured by that micrometer. Now divide B A C in *seconds* by the number of micrometer divisions used in taking it, and the result will be the value of each division of the micrometer in seconds and decimals of a second. As the value of the divisions may not be exactly the same in both micrometers their values must be separately determined. It should be

borne in mind that the values of the micrometer divisions must be determined at solar focus and the instrument used subsequently at solar focus, otherwise wrong values will be given for the micrometer divisions.

Example.—Number of divisions used (Right Micrometer), 1157·1; length of rod, 12 feet; distance between rod and instrument, 983·2 feet.

Log 12 = 1·079181
Log distance 983·2 = 2·992642

$\bar{2}$·086539
Cosecant of 1″ = 206265 Log = 5·314425

The whole ∠ = 2517″·46 = Log 3·400964

$$1157{\cdot}1)\ 2517{\cdot}460''\ (2{\cdot}17''\ \left\{\text{Value of each division.}\right.$$

23142

20326
11571

87550
80997

The same process would have to be gone through to find the value of a division of the Left Micrometer.

In combination with this instrument a rod of known length is generally used. Fig. 14 represents a rod devised by Lt.-Col. St. G. C. Gore, R.E., late Surveyor-General for India.

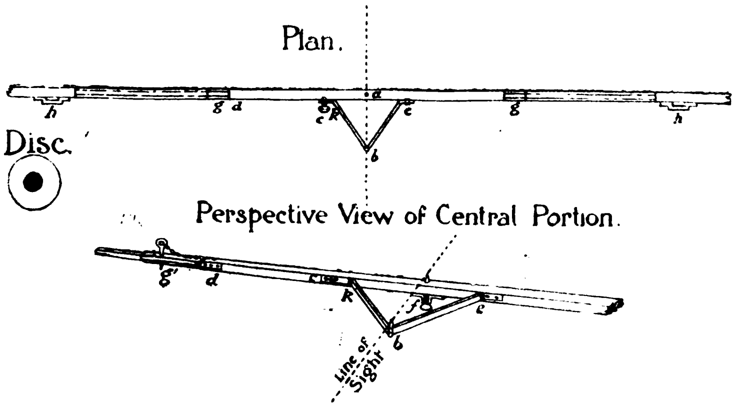


FIG. 14.

The bar is made of hard wood in three sections. The central section is square in cross section 1⅜ × 1⅜ inches with iron sockets six inches long,

g g, at each end, into which the outer portions of the bar fit, being pinned into place by the pins *g′*. The outer ends of the bar carry iron sockets, *h h*, which have the recesses in them accurately machined out. Into these sockets the discs fit by means of carefully-fitted hooks on their backs. The discs are of wood ten inches in diameter, painted white with a black ring. Black cloth covers are also carried to fit tightly over the discs, in case of working with a light background.

In the centre of the bar is a brass socket-plate, by means of which the bar can be attached to a tripod.

The sighting arrangement consists of a light iron frame, hinged at *e*, *b* and *k*. The pin of the hinge *b* carries a point on the top, and a similar metal point is fixed at *a* in the centre of the bar. The end of the frame *e* is screwed to the bar, and the other end is fixed by a thumbscrew *c* in such a position that the line joining *b a* is at right angles to the line joining the discs. For travelling, the thumbscrew *c* is unscrewed and the frame is closed up against the bar, in which position the thumbscrew screws into the hole *d* in a metal plate affixed to the bar. The bar is fixed in position by an assistant looking along the sights *a*, *b*, and laying them on to the theodolite.

Fig. 15 represents another form of rod and one more easily made, though not calculated to give such accurate results. A A are two

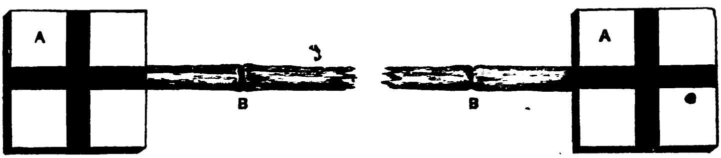


FIG. 15.

boards, one foot square, painted white, with a black cross on each. These are fastened on a bamboo, B B, in such a manner that the centres of the crosses shall be a known distance apart.

When using the rod in a vertical position it will often be found convenient to fasten a stick to it, so that it shall extend about two feet beyond one of the boards. This, when placed on the ground, takes the weight of the rod and helps the assistant to keep it steady.

Any theodolite can be used as a tacheometer, by having hairs in th

diaphragm fixed at such a distance apart as to read one foot on a staff when it is one hundred feet distant from the instrument, two feet when the staff is two hundred feet distant, and so on, and a theodolite fitted in this manner will always give a proportion of 1 to 100 between the reading on the *graduated* staff and the distance. As the power of the telescope is usually small, the figures and marks on the graduated staff can only be read at a comparatively short distance.

The following precautions must be taken, or no accurate results can be obtained. The fixed hairs must be adjusted to read in the proportion of 1 to 100, or, what is the same thing, the staff must be marked to read one foot when it is 100 feet distant from a certain point. It is the determination of where this point is that is absolutely necessary, and the place from which to measure the distance is arrived at in the following manner:—Mark the ground immediately under the centre of the instrument by dropping the plummet from the centre of the tripod, in the usual manner, and from this measure a distance, in the direction the telescope points, equal to the focal length of the object-glass, added to the distance from the object-glass to the vertical centre of the instrument. Thus, if the focal length of the object-glass was 12 inches, and the distance of the object-glass from the vertical centre of the instrument was 7 inches, then the position of the point from which to commence the measurement of the 100 feet would be 19 inches from the place where the plummet let fall from the centre of the tripod touched the ground. The telescope must always be set to *solar focus*, otherwise no accurate results can be obtained.

To all distances measured in this manner a constant, equal to the focal length of the object-glass plus the distance of the object-glass from the vertical centre of the instrument, must be added, otherwise there will be an increasing error in each distance measured. (*For instructions for using this instrument in the field, see pp.* 150–152.)

George's Mercurial Barometer.

Many attempts have been made to construct a mercurial barometer for the determination of heights, suitable for explorers and surveyors, but taking all things into consideration there is none better than that devised by the late Captain C. George, R.N., of which a sketch is here

FIG. 16.—GEORGE'S MERCURIAL BAROMETER.

given. The tubes are carried empty and filled on the spot, by means of a spiral cord with a feather attached. The barometer is simple in construction and has been found to give excellent results. In high mountainous regions the filling is at times difficult owing to the cold, but the process under ordinary circumstances should not occupy more than about a quarter of an hour.

The following are the instructions for filling the barometer:—Take the tube out of the tripod stand, unscrew the short part of brass tube, and take out the glass tube; insert it carefully into the cistern with a screw-like motion through the rubber plug until the end of the tube is opposite the mark in the middle of the cistern. Then screw on the smaller half of the brass tube, and pass it down through the top of the stand (cistern uppermost) until it rests on it, tie a stone or any suitable weight on the end of the tube to keep it down. Take off the bottom of the cistern, and thrust the feather end of the spiral cord down to the bottom of the tube. Now take the filterer and pour the mercury down the orifice of the tube until the cistern and tube are filled. Give the spiral cord circular motion from right to left until it works itself out of the tube, when fill in mercury up to the top of cistern.

Screw on the lower stopper tight, take the barometer out of the stand, and invert it: try if it gives a sharp metallic click-like sound: if it does not, there will be air in the tube, and the whole process must be repeated. Pass it upwards through the centre of the tripod stand, guiding the projecting arms through the notches, and, giving it a quarter turn, put it in its place, where it will swing perpendicular.

Let it rest a few minutes, read off the upper scale *first* and then the lower; their *difference* is the true reading if the zero is immersed in the mercury; but their *sum* if the zero is above the mercury in the cistern.

To Empty the Barometer.—Screw down the flange, and thus secure the mercury in the cistern.

Take the barometer out of the stand. Reverse it carefully, and unscrew the lower cap, tapping it gently to shake off the globules into the cistern.

Empty out the mercury into the wooden box, holding the fore-finger across the lower part of the orifice of the cistern. This prevents its rush-

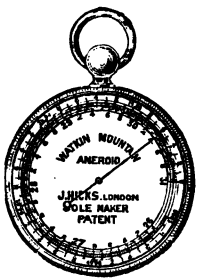
ing out too quick, and avoids spilling the mercury. Place the empty barometer in its stand.

Pour the mercury from the wooden box into the iron bottle. Secure it by the screw plug.

Clean the tube and cistern, inside and out, and it will be ready for re-filling again, or being put away in its stand and case.

Watkin Mountain Aneroid.

There can be no doubt that of the various instruments for determining the difference of altitude depending upon the change of atmospheric pressure, a simple form of the mercurial barometer such as George's is the best, whilst the ordinary aneroid is the least reliable of all, and at great altitudes the readings, unless they are checked by those of some other instrument, are quite useless. The late Colonel H. Watkin, how-



Front.

Back.

FIG. 17.—WATKIN MOUNTAIN ANEROID.

ever, has invented a mountain aneroid that has been reported by several travellers who have carried it to be a decided improvement on the usual form, although too much reliance should not be placed upon it, as in some instances it has proved unsatisfactory. The general appearance of this instrument is shown in the annexed figure. In ordinary circumstances it acts as any other aneroid, but when ascending a mountain, after the reading has been taken at the base, the Watkin aneroid can be

thrown out of action by turning the screw, shown in the sketch of the back of the aneroid, to the left, which has the effect of closing the vacuum box. It is then not affected by any change in the atmospheric pressure, and in this condition is carried to the top of the mountain. When this point is reached the screw is turned the opposite way, which puts the instrument into working condition again, and a reading is taken *immediately*, after tapping gently to see that the pointer is free. Before descending, the aneroid is again thrown out of action, and on reaching the lower station the screw is once more turned to the right, and another reading taken without delay. It is important that the readings should be taken immediately after the instrument is put into action. The instrument should not be carried for any length of time out of action, and unless actually employed in determining great differences of height, should be kept in working condition.

This aneroid is made in aluminium case by Mr. J. J. Hicks, of 8, 9, and 10, Hatton Garden, and the size most suitable for travellers is about three inches in diameter. It can be obtained with the scale divided either in inches or millimetres, and the price varies from £5 15s. to £6 17s. 6d. according to the range of altitude. When great altitudes have to be determined it is better to have two instruments constructed, one to read, say to 7000 or 10,000 feet, and the other to begin reading at this altitude and continue as far as necessary.

The Ordinary Aneroid.

The general appearance of the aneroid of usual construction is so well known that it requires no special description. It is an excellent instrument for laying down contour lines where the vertical interval is large; but for absolute heights it should be checked by the mercurial barometer, because its index error is apt to change; when thus checked it is a valuable instrument for measuring heights up to 5000 feet, but at greater elevations it is unreliable. It should be sent to the National Physical Laboratory to be tested, and have its errors determined before and after it has been used by a traveller for the purpose of measuring heights, and during the journey every opportunity should be taken of comparing it with mercurial barometers.

In the majority of cases, aneroids, even when they have been in the first

instance correctly graduated, do not read accurately against the mercurial barometer at diminished pressures, and will be found almost always to possess more or less considerable plus or minus errors. These errors are tolerably constant in good instruments, though they are frequently considerably augmented when low pressures have been experienced for a length of time.

Aneroids should be treated with almost as much care as chronometers, and should not be allowed to dangle about the person, or to be shaken up in pockets. If the watch size is employed, they can be conveniently carried in extra watch pockets.*

Measurement of Heights with the Aneroid.—To measure the difference in height between two stations, two instruments should be used, and the readings taken simultaneously at both stations; but it frequently happens that this is impossible, in which case the observations should be taken in the following manner:—State date and hour of observation; take the reading of the aneroid and the temperature of the air, *in the shade*, at the lower station; repeat this at the upper station, and again at the lower station on returning to it, but before taking this last reading a short time should be allowed to let the aneroid take up its proper working, as a descent will always, in a greater or less degree, affect it, unless a Watkin aneroid is used.

In observing with the aneroid, the instrument should always be in the same position, as, for instance, with its face vertical; merely altering the position affects most aneroids with a very sensible difference of reading.

On leaving a station to which it is not intended to return, the reading of the aneroid should be taken, and the temperature in the *shade;* during the day's journey the difference between any reading and that taken at starting will approximately give the difference of height unless there has been some atmospheric change. This is only a very rough way of ascertaining whether a party, passing through a hilly country, has ascended or descended; for the accurate method of computing the difference of height of two stations, see examples (pp. 189–193).

* On this subject the traveller will do well to read Mr. E. Whymper's book, 'How to use the Aneroid Barometer' (J. Murray, London), and his remarks on the "Watkin Mountain Aneroid" in *The Geographical Journal*, January, 1899.

Hypsometrical Apparatus.

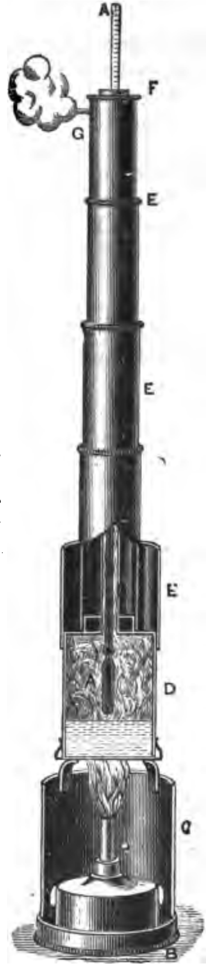


FIG. 18.

The boiling-point apparatus consists of a thermometer A, generally graduated from 180° to 215°; a spirit lamp B, which fits into the bottom of a brass tube C, that supports the boiler D; and a telescopic tube E, which fits tightly on to the top of the boiler. The thermometer is passed down the tube E from the top until within a short distance from the water, *which it should never touch*, and is supported in that position by an india-rubber washer F. The steam passes from the boiler up the tube E, and escapes by the hole G. To pack this instrument for travelling, withdraw the thermometer, and put it into a brass tube, lined with india-rubber, having a pad of cotton-wool at each end; take off the tube E, shut it up, and put the small end into the boiler D, which it fits, then withdraw the spirit lamp B, screw the cover over the wick and replace it in C. The whole of this apparatus fits into a circular tin case, 6 inches long, and 2 inches in diameter.

To use the Boiling-point Thermometer:—Take the apparatus to pieces, pour water into the boiler D—about one quarter full is quite sufficient; then put the instrument together as shown in the drawing, taking care that the thermometer is just clear of the water, and light the spirit lamp; as soon as the water boils, the steam ascending through the tube E will cause the mercury to rise; wait until the mercury becomes stationary, and then read the thermometer; at the same time, take the temperature of the air in the shade with an ordinary thermometer.

If the traveller is visiting a region where the elevations are very great, he should, when purchasing this apparatus, see that the thermometers

are capable of registering a greater height than those which are usually supplied. It is also important to see that the lamp is large enough to hold a good supply of spirit, as it is a common fault to make it too small; and the tube carrying the wick should be long to prevent overheating the spirit. A screen, which may be made of tin to fold up, is most useful to place on the windward side, and at a very low temperature is almost indispensable, as the heat is otherwise carried off too rapidly for the water to boil properly. A height ascertained by this method may be expected to be 100 feet or so in error.

Compasses.

Prismatic Compass :—This instrument consists of a magnetic needle A, balanced on a pivot B, carrying an aluminium ring C, divided into

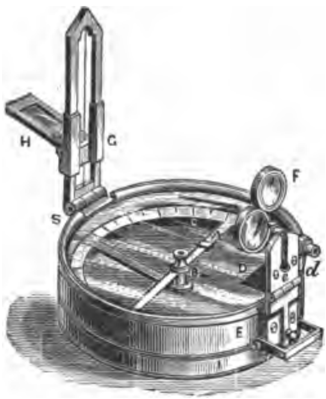


FIG. 19.—PRISMATIC COMPASS.

360°; it is graduated from the *south* pole of the needle,—by west, north, and east to south again, from 0° to 360°; the 0° is not shown on the ring, since it coincides with 360°. A prism D is fixed on one side of the box E, mounted on a hinge-joint *d;* it can be turned down when not in use, and is attached to a plate *e*, which slides up and down to suit the vision of the observer. In the plate there is a slit through which the observer looks; it has also an arm with two dark glasses F, to

protect the eye when taking a bearing of the sun. On the opposite side of the box is a sight-vane G, having a fine thread down its centre, and a mirror H, which slides on and off as required; it can be used with its face up or down, so as to reflect the sun or any object which cannot be directly observed. The sight-vane is also fitted with a hinge-joint, and when shut down, presses on a lever which lifts the needle off the pivot. In front of the sight-vane there is a small stud S, by pressing which with the finger the ring is brought to rest; it also serves to check the vibration of the needle. The box E has a cover I, which fits either the top or

FIG. 20.—POCKET COMPASS.

bottom, in which latter position it is shown in the drawing, and with it the instrument can be held when taking an observation. The prismatic compass is frequently fitted to screw on to a light tripod, with a ball and socket adjustment, and can then be used with greater accuracy either for taking bearings, or as an angular measuring instrument.

A prismatic compass * is not suited for taking bearings, except through the prism, on account of the reversal of the figures, and their arrange-

* The Army pattern of compass has two rings of figures, one for direct reading, and one for use with the prism.

ment from the south point; it will therefore be convenient, for taking rough bearings, for the traveller to provide himself with a pocket compass, having a card of the size and pattern shown in Fig. 20; it should be made of aluminium, which is both light and strong. The compass box should be fitted with a lever to throw the magnetic needle off its centre when the compass is not in use, and the glass should be thick flat crystal. For night work a luminous pocket compass will be found useful.

Observations with the Prismatic Compass:—To take an observation with the prismatic compass, first adjust the prism by sliding it up and down until the divisions on the circle are seen distinctly; if a tripod stand is used, screw the compass to the ball-and-socket joint, and move the instrument until it is perfectly horizontal (the same precaution must be taken if it is held in the hand); raise the sight-vane, until it is perpendicular; look through the slit in the prism-plate, and bring the thread of the sight-vane in a line with the object; wait until the magnetic needle comes to rest, and read the bearing through the eye-hole in the prism-plate. A bearing thus taken shows the angle which a straight line drawn from the observer, to the object, makes with the magnetic meridian, and is called the magnetic bearing.

To get the true bearing the magnetic variation must be applied as follows:—If the variation is east *add* it to the bearing, if west *subtract* it, and the result in either case will be the true bearing. Thus: the magnetic bearing of an object was 160° and the variation 20° east, then $160° + 20° = 180°$, the true bearing; the bearing of an object was 160° and the variation 20° west, then $160° - 20° = 140°$, the true bearing; but since the magnetic needle will be affected equally by variation within certain limits of time and space, the difference of the bearing of any two objects, taken from the same station, will be the *angle* subtended by them, as the *difference* in their azimuths will not be affected by the variation.

Where possible, the bearings should be taken at both ends of a base, or line of bearing, the mean of which will be the correct bearing. When the sun's azimuth or amplitude has to be taken, one of the dark glasses should be placed before the slit in the prism-plate, and the mirror should be moved on the sight-vane until the reflected image of the sun is seen in the mirror through the slit in the prism-plate; the bearing is then

taken in the manner before described. Great care must be taken when using this instrument to avoid all magnetic rocks, as they may so affect it as to render bearings taken in their vicinity useless.

Heliostat.

A flash from a small mirror is of the greatest use in surveying. Mirrors mounted so as to turn in any direction are sold by opticians under the name of heliostats, and a flash from one of two inches square may be seen fifty miles. It requires, however, an intelligent person to direct the mirror, and it cannot therefore be worked by a native or untrained European. Mirrors fitted for this purpose are made of accurately parallel plate glass, and a small hole is made in the silvered surface and the plate protecting the back of the glass.

Planting the stand of the mirror fairly, the hole in the centre is looked through, and a piece of paper working on a stick, which must be stuck in the ground about ten paces distant, is brought into exact line with the object to which it is desired to flash and when the observer is in readiness to take the angle to the flash. The mirror is then turned about until the flash from the sun illuminates the paper, when the observer at the distant point will also see it. The flash must be kept carefully on the paper until an answering flash shows that it has been seen and observed.

Two surveyors working together in this way can obtain most accurate observations without any time being expended in erecting marks. In a persistently cloudy climate, the method is, of course, of little use.

A very simple form of heliostat, suitable for surveying purposes, consists of a circular mirror held in a brass frame by two screws which, when turned, cause the mirror to oscillate. In the centre of the mirror is a small hole through which the surveyor at one station looks to direct the flashing of the rays upon a surveyor at any other distant station, who himself has another similar heliostat, and who, when he sees the flashing, signals back to show that this is the case. A second mirror is attached for reflecting the sun on to the signalling mirror when it is behind the signaller. The frame of the mirror is supported by a light stand with an arrow point for sticking it into the ground. The stand is hollow, and when not being used the arrow point can be placed inside the tube for convenience of carrying.

PART III.

FORMULÆ OF PLANE AND SPHERICAL TRIGONOMETRY, EXTEMPORARY MEASUREMENTS, SCALES AND PROJECTIONS OF MAPS.

Space will not permit here of treating of the theory of trigonometry; and for this reason Mr. E. A. Reeves has prepared a special text-book, 'Plane and Spherical Trigonometry,' in which the principal formulæ employed in these 'Hints' are investigated. This can be obtained at the Society's office. The information here given is entirely practical.

The following formulæ are of frequent use in all surveying problems. In right-angled triangles, B being the right angle, if A or C is known, the other is found by subtracting the known angle from 90°. For the rest we have:—

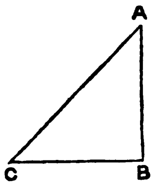


FIG. 21.

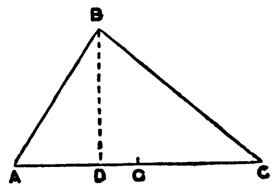


FIG. 22.

TABLE I.

Case.	Given.	Required.	Solution.
1	Hyp. A C Angles	Base C B.. Perp. A B	C B = A C × cos C. A B = A C × sin C.
2 & 3	Base C B Angles	Perp. A B Hyp. A C	A B = C B × tan C. A C = C B × sec C.
4 & 5	Hyp. A C Perp. A B	Angles .. Base B C	sin C = A B ÷ A C; cos A = A B ÷ A C. $BC = \sqrt{(AC + AB) \times (AC - AB)}$.
6	Perp. A B Base B C	Angles .. Hyp. A C	tan C = A B ÷ B C; cot A = A B ÷ B C. A C = B C × sec C.

TABLE II.

Case.	Given.	Required.	Solution.
1	The angles and side A B.	Side B C Side A C	$BC = AB \times \sin A \times \text{cosec } C.$ $AC = AB \times \sin B \times \text{cosec } C.$
2 & 3	Two sides A B, B C, and angle C opposite to one of them.	Angle A Angle B Side A C	$\sin A = \sin C \times BC \div AB.$ $B = 180^\circ - (A + C).$ $AC = AB \times \sin B \times \text{cosec } C.$
4 & 5	Two sides A B, A C, and the included Angle A.	Angles C and B Side B C	$\tan \frac{B - C}{2} = (AC - AB) \times \cot \frac{A}{2} \div (AC + AB).$ and, $\frac{B + C}{2} = 90^\circ - \frac{A}{2}$: from which $B = \frac{B + C}{2} + \frac{B - C}{2}$: and $C = \frac{B + C}{2} - \frac{B - C}{2}.$ $BC = AB \times \sin A \times \text{cosec } C.$
6	All three sides.	All the Angles	From half the sum of the three sides, subtract, separately, each of the three sides. Multiply these four numbers (the half sum and the three remainders) together, and take twice the square root of the product. This result, divided by the product of any two of the sides, gives the sine of the angle between them.

In all plane triangles, if two of the angles are known, the third angle is found by subtracting the sum of the two from 180°.

The foregoing equations may be solved by multiplication and division, with a table of natural sines, cosines, &c.; but, in order to avoid such a tedious process, logarithms are usually employed. In calculating with logarithms, multiplication is performed by adding together the logarithms of the numbers to be multiplied: the sum is the logarithm of the product: division is performed by subtracting the logarithm of the divisor from the logarithm of the dividend; the remainder is the logarithm of the quotient. *Twice* the logarithm of a number is the logarithm of its square; and *half* its logarithm is the logarithm of its square root.

The following are some of the most useful examples of the practical application of the rules given in Tables I. and II.:—

(1.) To ascertain the height of a point C (Fig. 23), which cannot be approached nearer than B, observe the angle of altitude C B D = 46°,

and measure the distance from B to A = 200 feet, at which place the angle C A B = 29°.

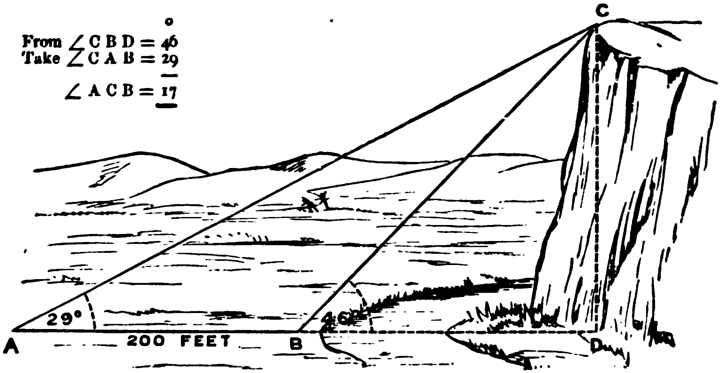


Fig. 23.

Having found the ∠ A C B as below, compute the length of B C by *Case* 1, *Table II.* Then, as the ∠ C D B = 90°, compute the height C D by *Case* 1, *Table I.*

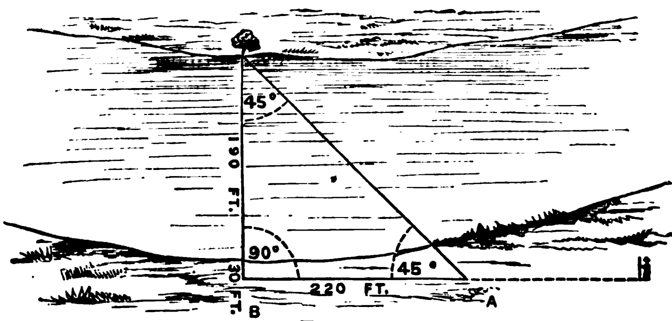


Fig. 24.

(2.) To measure the breadth of a river when standing at B (Fig. 24), a short distance from it, send on a man with a staff to a distance judged to

be greater than the breadth of the river. Then motion him to the right and left until he is in such a position that the reflected image of the staff is shown exactly over a tree on the opposite bank (as seen directly) when 90° was read on the arc of the sextant: having set the sextant to 45°, walk in a straight line towards the staff until a position, A, is reached, where, on looking through the sextant, the reflected image of the tree is shown exactly over a mark set up at B (as seen directly). Then measure the distance from A to B, which is found to be 220 feet; from this subtract 30 feet, the distance from the water, and this will give the breadth of the river, 190 feet.

$\angle A$ 75°   180°
$\angle B$ 40°   115
115   $\angle C = 65$

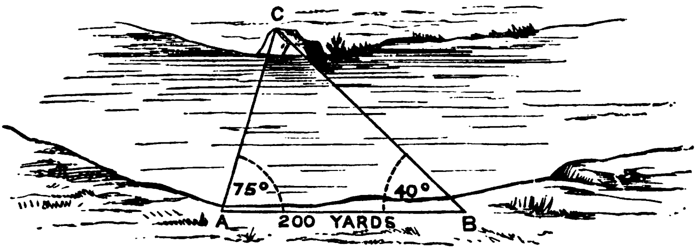


FIG. 25.

(3.) To measure the breadth of a river set up a mark, A (Fig. 25), close to the water; from point A measure a base of, say, 200 yards, parallel to the course of the river, and set up another mark, B. The angles subtended by a rock on the opposite bank and each end of the base, were A 75°, B 40°. Then compute the breadth of the river by *Case* 1, *Table II.*

(4.) To ascertain the height of an inaccessible point, A (Fig. 26), above the position C, measure the angle of elevation with a theodolite. Suppose this to be 40°. As a river behind prevents the taking of a base in that direction, one is measured 200 yards to the left of C and a mark

set up at D. The angles subtended by A, at each end of the base, were found to be, C 94°, D 63°; with these angles and the base C D, compute the side B C by *Case* 1, *Table II*. Then, as B C is the base of the right-

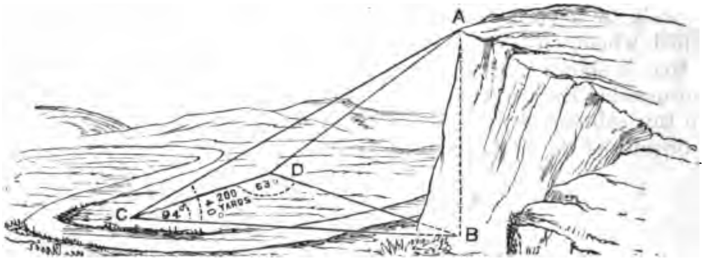


FIG. 26.

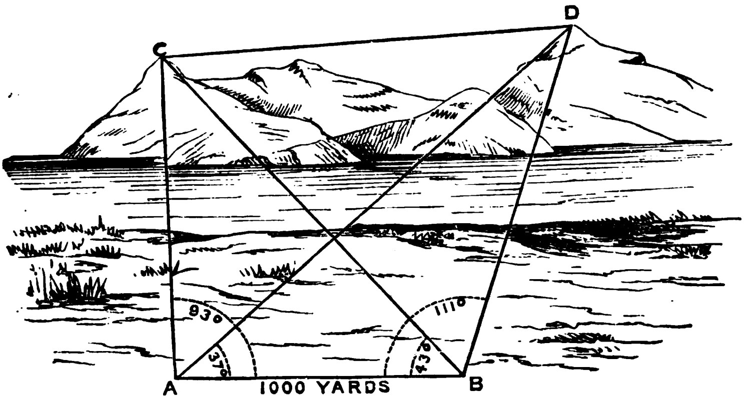


FIG. 27.

angled triangle A B C, compute the height of the A by *Case* 2, *Table I*. Should a sextant be used, the angles A C D and A D C will be taken, and with these, and the base C D, compute the side A C by *Case* 1, *Table II*.

Then as A C is the hypotenuse of the right-angled triangle A B C, the height of the point A can be computed by *Case* 1, *Table I.*

(5.) The distance between two inaccessible peaks C and D (Fig. 27) being required, measure a base, A B, of 1000 yards, setting up a mark at each end. Then measure the angles between the two peaks, at both ends of the base; suppose them as follows:—at A, 37° and 93°; at B, 43° and 111°. In the triangle A B C, by subtracting the sum of angles A and B, = 136°, from 180°, the angle C is found to be 44°; by a similar process the angle D in the triangle A B D is found to be 32°, and in the triangle B C D, by subtracting 43°, the smaller angle, from 111°, the greater, the angle at B is found = 68°. Having thus found all the necessary data in the triangle A B C, compute the side C B (*Case* 1, *Table II.*), and in the triangle A B D, compute the side D B (*Case* 1, *Table II.*). With the sides C B and B D, of the triangle B C D and the included angle B, compute the side D C (the distance between the inaccessible peaks) by *Cases* 4 and 5, *Table II.*

In computing the difference of height between points, when the distance exceeds one mile, a correction has to be applied for curvature of the earth and refraction of the atmosphere. The method of doing this is shown on p. 185.

Spherical Trigonometry.

In any spherical triangle the sines of the sides are proportional to the sines of the opposite angles, or $\frac{\sin A}{\sin B} = \frac{\sin a}{\sin b}$.

Given three sides, a, b, c (Fig. 28)

$$\sin^2 \frac{A}{2} = \frac{\sin \frac{a+b-c}{2} \cdot \sin \frac{a-b+c}{2}}{\sin b \sin c}$$

or, where

$$s = \tfrac{1}{2}(a+b+c), \quad \sin \frac{A}{2} = \sqrt{\frac{\sin(s-b)\sin(s-c)}{\sin b \sin c}},$$

$$\tan \frac{A}{2} = \sqrt{\frac{\sin(s-b)\sin(s-c)}{\sin s \sin(s-a)}},$$

Given two sides, and included angle, a, b, C,

$$\tan \frac{A+B}{2} = \frac{\cos \frac{1}{2}(a-b)}{\cos \frac{1}{2}(a+b)} \cot \frac{C}{2},$$

$$\tan \frac{A-B}{2} = \frac{\sin \frac{1}{2}(a-b)}{\sin \frac{1}{2}(a+b)} \cot \frac{C}{2},$$

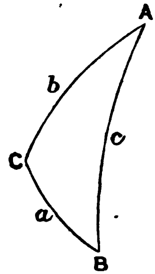


FIG. 28.

Given two sides and angle opposite one of them, a, b, A.

$$\text{Let } \tan \theta = \tan b \cos A,$$

$$\cos \theta' = \frac{\cos \theta \cos a}{\cos b},$$

$$\text{then, } c = \theta \pm \theta' \text{ (two solutions).}$$

Given three angles, A, B, C,

$$\cos a = \frac{\sin (A+\theta)}{\sin B \sin C \sin \theta}$$

$$\text{where } \cot \theta = \frac{\cos B \cos C}{\sin A}.$$

Given two angles and adjacent side, A, B, c,

$$\cos C = \frac{\cos A \sin (B-\theta)}{\sin. \theta},$$

$$\text{where } \cot \theta = \cos c \tan A.$$

$$\text{or, } \tan \frac{a+b}{2} = \frac{\cos \frac{1}{2}(A-B)}{\cos \frac{1}{2}(A+B)} \tan \frac{c}{2},$$

$$\tan \frac{a-b}{2} = \frac{\sin \frac{1}{2}(A-B)}{\sin \frac{1}{2}(A+B)} \tan \frac{c}{2}.$$

Given two angles and side opposite one of them, A, B, a.

$$\text{Let } \cot\theta = \tan B \cos a$$

$$\sin\theta' = \frac{\sin\theta \cos A}{\cos B} \quad \text{(two solutions)}$$

$$\text{then, } c = \theta \pm \theta'.$$

Napier's Circular Parts Rules for the Solution of Right-angled Spherical Triangles:—Ignoring the right angle B (Fig. 29) *entirely*, there are five "parts," so-called: the perpendicular c, the base a, the *complements* of the angles A and C, and of the hypotenuse b. Any one of these may be the middle part, and the two others are either adjacent parts or opposite parts, according to whether they are *next* to the middle part, or have a part between them and the middle part. Remembering this, the rules for the solution of the triangle are:—

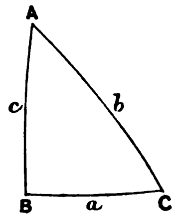


FIG. 29.

Sine of middle part = product of tangents of adjacent parts.
Sine of middle part = product of cosines of opposite parts.

USEFUL APPROXIMATE METHODS AND EXTEMPORARY MEASUREMENTS.

To find the Meridian by a Watch.

When the sun is visible, the position of the meridian line can be approximately determined in the following manner by a watch set to local time:—Turn the face of the watch to the sun in such a manner that the hour-hand shall point to the sun, or, in other words, until the hour-hand itself shall be directly over its shadow. Half-way between the place of the hour-hand and XII. will be the south point in north latitude, and the opposite point of the dial will be the north point. In south latitude point XII. at the sun instead of the hour hand. This rough method should not be used in the tropics.

To find the Meridian by the Sun, without Instruments.

Having levelled a piece of ground of sufficient size, plant a rod in a truly perpendicular position, testing it with a plumb-line, and at an hour or two before noon (say 10.30) mark accurately the extremity, C, of the

shadow, B C, thrown by the rod when the sun is in the position S; then from the base, B, of the rod as a centre, with the radius B C, the length of the shadow, describe the circle, D C F, upon the ground. As the sun's altitude increases, the shadow of the rod will fall within the circumference of the circle, and will gradually grow shorter until noon; after which, as the sun's altitude decreases, the shadow of the rod will grow longer until, at last, when the sun has attained the position S′, it will reach the circumference of the circle at the point D. Divide the arc C D into two equal parts, and from E, a point equi-distant from C and D, draw a line through the centre B, and that line will coincide, approximately, with the true meridian.

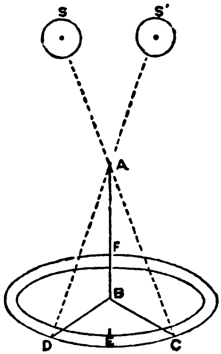


FIG. 30.

To set off a Right Angle from any Point on the Ground by Means of a Rope.

To set off, from any point A (Fig. 31), a line at right angles to a given direction, as A E, measure an equal distance on each side of A, in the same straight line as A E, this equal distance *being about one-fourth of the length of the rope.* Let C and D be these points. Fasten the ends of the rope at C and D, and having ascertained the centre of the rope by doubling it, the centre should be drawn out towards B, until D B and C B are tight. Then E A B will be a right angle; therefore, as we are thus able to set off a right angle to any line, the distance of any inaccessible object may be obtained by either of the three following ways:—

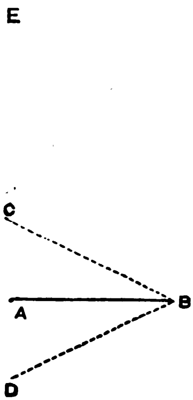


FIG. 31.

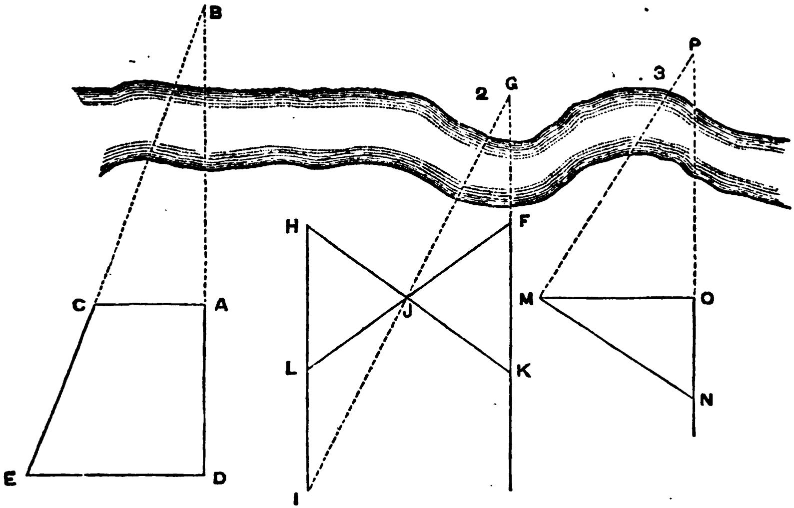
To find the Distance of an Inaccessible Object with a Measuring Line.

By Fig. 32, Case 1.—From the line A D measure off the perpendiculars A C, D E, ranging the point C in line with E B, then

$$A\,B = \frac{A\,C \times A\,D}{D\,E - A\,C}.$$

By Fig. 32, Case 2.—Fix any convenient points H and K. Join H K and bisect it in J; make J L = J F, and range I in line with H L and with J G; then L I = F G.

FIG. 32.



By Fig. 32, Case 3.—Set off O M at right angles to O P, and M N at right angles to M P; then $O P = \frac{O M^2}{O N}$.

ROUGH METHODS OF MEASURING.

Rough angular measurements may be taken by the span at arm's length. From the end of the thumb to the end of the middle finger subtends an angle of 15°; the full span to the end of the little finger subtends an angle of 18°. This may be easily checked by spanning round the horizon; twenty spans make the circuit. It is at all times well to know the length of the different joints of the limbs. Suppose the nail-joint of the forefinger to be 1 inch, the next joint will be 1¼ inches, the next 2 inches, and from the knuckle to the wrist 4 inches; in this case

the finger is bent, so that each joint may be measured separately, though, when held straight, the distance from the tip of the forefinger to the wrist would be only 7 inches. The span with thumb and forefinger would be 8 inches, and with the thumb and any of the other three 9 inches, or equal to the length of the foot; from the wrist to the elbow would be 10 inches, and from elbow to forefinger 17 inches, and from collar-bone to forefinger 2 feet 8 inches; height to the middle of the kneecap 18 inches. From the elbow to the forefinger is usually called a cubit, but it is seldom strictly so, an English cubit being generally stated as 18 inches. In like manner the full stretch of the extended arms is called a fathom; but it is generally somewhat less.

The pace is commonly supposed to be 2½ feet, but this is a most uncertain mode of measurement. Very few men, *without practice*, can take correctly a hundred consecutive steps or paces of the same length. Practice will determine the amount of ground covered in a certain number of paces, if tried over known distances; it of course varies, but from experiment the mean has been found nearly as follows:—

Pacing, at 30 inches per pace, of 108 in a minute, equals 270 feet, or 3·068 statute, or 2·66 geographical miles per hour.

Pacing quickly, at 30 inches per pace, of 120 in a minute, equals 300 feet, or 3·41 statute, or 2·96 geographical miles per hour.

Pacing slowly, at 36 inches, may average 60 per minute, equals 180 feet, or 2·04 statute, or 1·78 geographical miles per hour.

Distance by Sound.

Sound travels at the rate of about 1090 feet in one second in calm weather and temperature 32° Fahr., and increases at the rate of 1·15 foot for each degree of temperature above 32°; a moderate breeze accelerates or retards sound by about 20 feet in a second. When a gun is used to measure distance it should always be pointed at an angle of about 45° to the horizon. This method will be found most useful in making rough surveys of winding rivers or lakes, where it is impossible to land on account of the dense undergrowth or the swampy nature of the banks. Greater accuracy may be obtained if a gun is fired at each end.

Measurement of the Number of Cubic Feet of Water conveyed by a River in each Second.

The data required are—the area of the river-section and the average velocity of the whole of the current. All that a traveller is likely to obtain, without special equipment, is the area of the river-section and the average velocity of the *surface* of the current, which is greater than that of its entire body, owing to frictional retardation at the bottom.

To make the necessary measurements, choose a place where the river runs steadily in a straight and deep channel, and where a boat can be obtained. Prepare a few floats of dry bushes with paper flags, and be assured they will act. Post an assistant on the river-bank, at a measured distance, of about half the estimated width of the river, down stream, in face of a well-marked object. Row across stream in a straight line, keeping two objects on a line in order to maintain your course. Sound at intervals from shore to shore, fixing your position on each occasion, by a sextant-angle between your starting-place and your assistant's station, and throw the floats overboard, signalling to your assistant when you do so, that he may note the interval that elapses before they severally arrive opposite to him. Take an angle from the opposite shore, to give the breadth of the river.

To make the calculation approximately, protract the section of the river on a paper ruled to scale in square feet, and count the number of squares

EXAMPLE.

DISTANCE FROM SHORE	Starting place.									Opposite Shore.	
Whence the boat started, measured in feet	0	90	160	240	330	420	500	600	700	780	
Depth at those distances measured in feet	0	2	3½	4	4	5½	7	6½	3½	0	
Time required for float to drift opposite to assistant, measured in seconds	0	48	50	40	33	29	27	30	50	0	Average 38·4

Distance of assistant, in feet, 150.

in the area of the section. Multiply this by the number of feet between you and the assistant, and divide by the number of seconds that the floats occupied, on an average, in reaching him.

Important rivers should always be measured above and below their

confluence; for it settles the question of their relative sizes, and throws great light on the rainfall over their respective basins. The sectional area at the time of highest water, as shown by marks on the banks, and the slope of the bed, ought also to be ascertained.

By protracting the data on the first two lines, on ruled paper as described above, it will be found that the area of the section is 3260 feet, or thereabouts; this, multiplied by 150, gives 489,000 cubic feet of water as the contents of the river at any given moment between the line of soundings and the assistant. As this amount passes by in 38·4 seconds, the number of cubic feet per second is the former number divided by the latter, which gives 12,734.

It must be distinctly understood that this number is only roughly approximate, and that it is excessive. However, with the above data, an engineer would be able to make a somewhat better calculation. In the meanwhile, the traveller might consider the flow of the river in question to be between 10,000 and 13,000 feet per second.

Scales of Maps.

The proportion that the area of the map bears to the country it represents is expressed as a fraction, thus $\frac{1}{250,000}$, or 1:250,000, which is called the R. F. (Representative Fraction) or the Natural Scale of the map. This, in fact, means that if the map were increased in linear dimension 250,000 times, it would be as large as the country shown upon it. By general consent it has now been decided by European countries and America to adopt the R. F. 1:1,000,000 as a standard, and it is recommended that all maps should be constructed on some even multiple of this scale, e.g., 1:500,000, which would, of course, be twice as large as 1:1,000,000; 1:250,000, or four times as large; 1:125,000, eight times as large, and so on. For practical geographical survey purposes the scale of 1:250,000 is generally recommended, but where much detail is required this would be too small, and 1:125,000 would be preferable.

Since there are 63,360 inches in one statute mile, it is clear that a map on the scale of R. F. 1:63,360 equals 1 inch to 1 statute mile, as one inch on the map represents 63,360 inches in nature. Therefore, when the R. F. or natural scale of a map is given, and it is desired to

find the corresponding miles to an inch, all that is necessary is to divide the R. F. by 63,360, thus:—$\frac{250,000}{63,360}$ = 1 inch to 3·945 statute miles; and *vice versâ* when the linear scale is known, or the number of statute miles to an inch, it is only necessary to multiply this number by 63,360 to obtain the R. F. When the R. F. is greater than 1:63,360 (such as 1:50,000, 1:20,000), it is usual to divide 63,360 by the R. F., and so obtain the number of inches to a statute mile; thus, take the case of R. F. 1:50,000:—$\frac{63,360}{50,000}$ = 1·267 inches to 1 statute mile. If the division had been as in the first case, the result obtained would have been the fraction of a statute mile in 1 inch, thus $\frac{50,000}{63,360}$ = 1 inch to 0·785 statute mile.

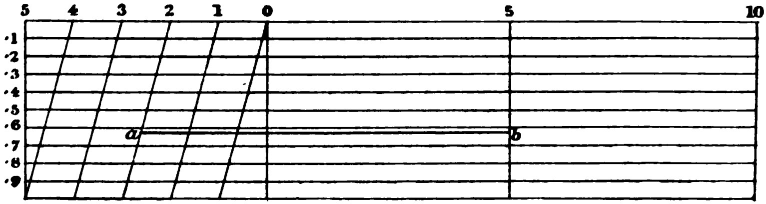
Diagonal Scales.—Having decided upon the R. F., or Natural Scale, upon which a plane-table survey is to be conducted, or the map drawn, and having computed the corresponding number of statute miles to an inch, the next thing to be done is to construct a diagonal scale of miles reading to tenths and hundredths of a mile, or on large scale plans, one reading to yards or feet. For this purpose a metal scale is required (such as Gunter's) about two feet long, upon which has been engraved a diagonal scale of inches reading to tenths and hundredths.

To draw a diagonal scale of miles proceed as follows, taking as an example the R. F. of 1:250,000, which equals 1 inch to 3·945 statute miles. Since 3·945 is an odd number, it would be extremely inconvenient to construct a scale with this measure, but by simple proportion the number of inches and decimals of an inch, representing an even number of miles *for the same scale*, can be readily found, and then the diagonal scale can be constructed without difficulty. Thus:—

miles.		inch.		miles.		inches.
3·945	:	1	::	5	:	1·267

Now draw a line of indefinite length in some suitable position on the map, and set off upon it as many times as convenient the measure of 1·267 inches, taken with a pair of dividers from the diagonal scale of inches. This measure will represent five miles on the scale. Set one of the 5-mile divisions back to the left of 0 on the scale, divide it into single

miles, and construct a diagonal scale, reading to tenths and hundredths of a mile, as shown below (Fig. 33). In this case the hundredths of a mile can be read with sufficient accuracy for practical purposes by estimation. For instance, the line *a b* on this diagonal scale is the measure of 7·62 statute



R.F. 1 : 250,000 or 1 inch = 3·95 stat. miles.
FIG. 33.

miles. If greater accuracy had been required the scale might be deepened. On larger scales set a single mile back to the left of the zero 0, and divide this measure on the top and bottom lines, as well as the perpendicular lines at the sides, into tenths. Then the tenths of miles could be read off on the former and the hundredths on the latter.

The R.F. or Natural Scale of a map on the scale of 1 kilometre to 1 inch is, neglecting decimals, $\frac{1}{39,371}$ so when it is desired to construct a linear scale of kilometres instead of miles, all that is required is to divide the R.F. by 39,371, instead of 1 : 63,000. Tables on pp. 340, 341 give the number of kilometres and versts in a statute mile.

MAP PROJECTIONS AND GRATICULES.

Where extensive areas of the earth's surface have to be represented on the map the projection best suited for the purpose has to be most carefully considered; for since it is impossible to represent any portion of the curved surface of the earth upon a plane without distortion of some kind, the distortion is enormously greater when a larger area has to be dealt with. However, the geographical surveyor rarely requires to represent any large area upon one sheet, and for the purpose of plane tabling a sheet taking in one degree of latitude and longitude is usually

quite sufficient. For him, therefore, the matter is simple, and the best form of projection for his purpose is that known as the Survey of India Projection.

Survey of India Projection.

The principle upon which this projection is constructed is as follows:—Suppose all the corner points of a degree square to be marked on the earth's surface, and a plane to cut through the curved surface and touch each of the four corners. Then if the points on the curved surface be projected upon the plane, it is evident that the error would be very slight indeed, and the map would be practically correct. Several of these projection sheets might be joined together without any appreciable error, but of course if it were attempted to join many they would not fit properly. For work in the field it is always better to construct a separate projection for each sheet, and not make one projection for several degrees and then cut it up into suitable sizes for the plane-table.

A table to facilitate the construction of this projection is given on p. 287, and the actual method of procedure for drawing the net work, or the graticules, as this is called, is as follows:—Let it be desired to construct a projection of 1° latitude and 1° longitude, between latitude 50° and 51° N.

(1.) Construct a diagonal scale of miles at the base of the map as shown previously (p. 88).

(2.) Through the centre of the map draw a line A B (Fig. 34) perpendicular to the base, representing the central meridian, and upon this line set off, from a point near the centre (C), which will represent 50° 30′ N., the value in miles of 30′ of latitude taken from the table (p. 287) where the values are given for every 15′.

(3.) In the same manner take the value of 30′ of longitude for the latitudes of 50°, 50° 30′, and 51°, and placing the point of the dividers on the central meridian A B, at the points cut by these parallels of latitude (A, C and B), sweep the arcs *a*, *b*, *c*, *d*, *e*, *f*.

(4.) Take the value of the diagonals C *f* and C *b*, for the proper latitudes, and with the point of the dividers at C sweep arcs intersecting the arcs *a*, *b*, *e*, *f*, on both sides of the central meridian, as shown.

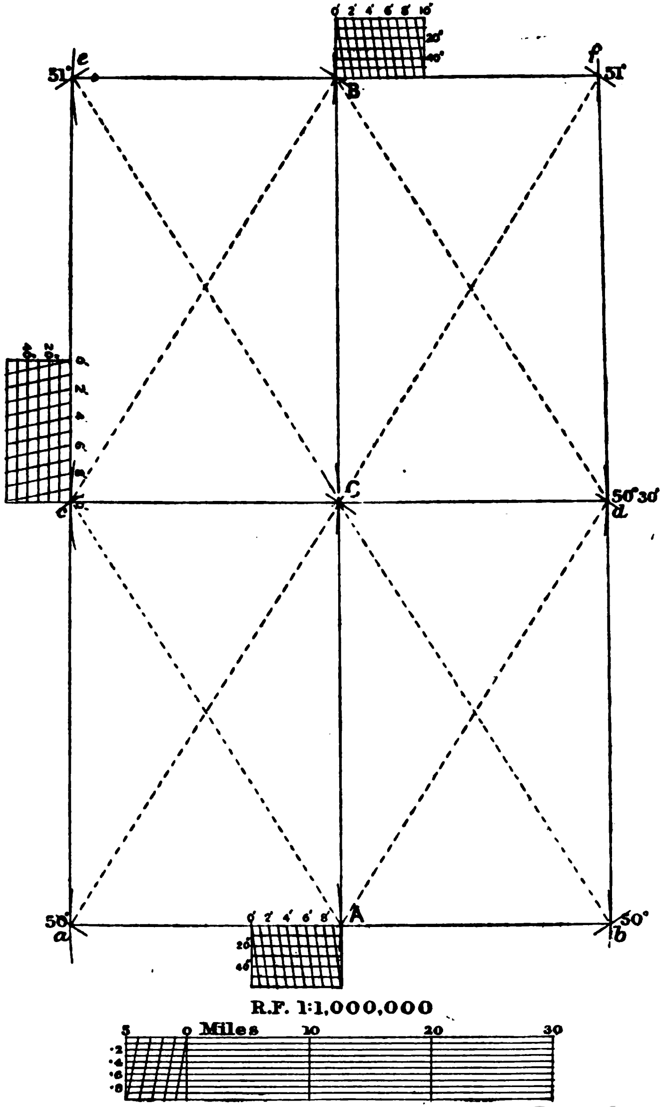


FIG. 34.

(5.) Lastly, connect the points *a* A, *b* A, *c* C, *d* C, *e* B, *f* B, by straight lines, or by suitable curves.

An example of this projection is given in Fig. 34.

For the laying down of positions on the projection it is necessary to construct diagonal scales reading to minutes and seconds of latitude and longitude, which can be done as shown in the example.

Conical Projection with Two Standard Parallels (*or Secant Conical Projection*).

When it is desired to construct a map including several degrees of latitude and longitude there is no better projection for general purposes than this. Two selected parallels are represented by concentric circular arcs of their true lengths; the meridians are their radii. The degrees along the meridians are represented by their proper lengths, and the other parallels are circular arcs through points so determined, concentric with the chosen parallels. The construction evidently fixes the centre of the parallels, for if p_1 and p_2 are the true lengths of one degree of longitude on the chosen parallels, m the length of the intervening meridian (all of which can be taken from Table IX.), then $h = \frac{p_2 - p_1}{m} \times \frac{180^*}{\pi}$, where h = ratio between the inclination of the meridians and their true difference of longitude.

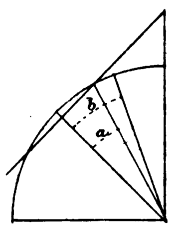


FIG. 35.

The two standard parallels upon which there would be no error in scale are often determined arbitrarily, or by dividing the central meridian into four equal parts and selecting those midway between the centre and extreme parallels; and in many cases this arrangement would be sufficiently correct for practical purposes. It is however preferable to adopt some regular system in the selection of the errorless standard parallels, and for general purposes it is well to select them so that the error in scale on

* $\frac{180^\circ}{\pi} = 57^\circ{\cdot}296$ nearly.

the extreme parallels shall equal that of the middle parallel. A simple approximate formula for determining these parallels is

$$\cos a = \frac{1 + \cos b}{2}$$

where a (Fig. 35) equals the distance in arc on the central meridian of each of the errorless parallels from the middle parallel, and b the distance in arc of the extreme parallels from the middle parallel.*

Applying the above to a projection of a portion of Central Asia, included between the parallels of 54° and 68° N. latitude and 33° and 47° E. longitude, we have for the errorless parallels:—

$$\frac{1 + \cdot 99255}{2} = \cdot 99627$$

which is the natural cosine of 5° nearly, and this is equal to the distance in arc of the errorless parallels from the middle parallel (61°). The parallels to select, which will be practically free from scale error, are therefore 56° and 66°.

The true length of 1° of longitude on parallel 56° = p_2 38·768 miles.†

" " " 66° = p_1 28·216 "

" of intervening meridian = 692·418 "

$$\text{Then } h = \frac{38 \cdot 768 - 28 \cdot 216}{692 \cdot 418} \times 57 \cdot 296 = \cdot 8731.$$

The radius of each of the parallels is now readily found, that for 56° being

$$\frac{\text{length of } 1^\circ \text{ of longitude at } p_2 \times m}{p_2 - p_1} = \frac{38 \cdot 768 \times 692 \cdot 418}{10 \cdot 552} = 2543 \cdot 94 \text{ miles.}$$

The radius of 66° = 2543·94 − 692·42 = 1851·52.

Next to calculate the co-ordinates for plotting. Take the parallel of 56° N. The radius of this parallel is 2543·94 miles. Take the meridian of 40° E. as the axis of y, and the intersection of this meridian with the

---

* The natural cosines may be taken from Table XXXVII., or, if greater accuracy is desired than can be obtained from this table, from the log cosines (Table XXXVII.) by looking up the number in Table XXXV., corresponding to the log cosine, ignoring the index in the latter.

† See Table IX.

parallel 56° N. as the origin. To determine the co-ordinates of the point 56° N. and 45° E. The angles between the meridians on map $= \cdot 8731 \times 5 = 4° 21' 56''$.

Then $x = 2543 \cdot 94 \times \sin 4° 21' 56'' = 193 \cdot 64$ miles.

$y = 2543 \cdot 94 \times (1 - \cos 4° 21' 56'') = 7 \cdot 38$ miles.

These co-ordinates are, of course, also set off on the other side of the central meridian.

The co-ordinates of the other points can be computed in the same manner, and then the projection drawn out to the required scale, using a diagonal scale of miles.

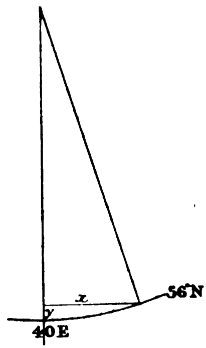


FIG. 36.

Equidistant Zenithal Projection.

For high latitudes perhaps the best projection for general use is the equidistant zenithal projection. In this projection, any point on the sphere being taken as the centre of the map, great circles through this point are represented by straight lines of the true length to scale, and intersect each other at the true angles. The position of the intersection of any meridian with any parallel is given (on the spherical assumption) by the solution of a simple spherical triangle.

Thus, if z_1 is the colatitude of the centre of the map,
z ,, ,, ,, any other point.
a ,, longitude of any other point from the central meridian.
A ,, required azimuth.
c ,, ,, spherical distance.

Let $\tan \theta = \tan z_1 \cos a$, then $\cos c = \cos z_1 \sec \theta \cos (z - \theta)$, and $\sin A = \sin z \sin a \operatorname{cosec} c$

Having found thus the azimuth A and the distance c, the position of z should be laid down on the map by rectangular co-ordinates which can now readily be computed.

PART IV.

GEOGRAPHICAL SURVEYING AND MAPPING.

The most accurate method of conducting a survey is by an elaborate and carefully arranged system of triangulation, and all the more important countries of Europe, India, and a considerable area of the United States have been surveyed in this manner, while the triangulations of South Africa, Algeria, and some other parts of the world are well advanced. However, such surveys necessarily make slow progress, and as a rule take many years to complete, besides being very costly, and it is therefore often most desirable, especially in newly settled countries, that some more rapid and less expensive system of surveying should be carried on until the final large scale survey can be undertaken—some survey which, while not attempting the accuracy and refinement of a regular triangulation, shall give the leading geographical features and details with sufficient accuracy for all practical purposes. It is a mistake to suppose that because a large trigonometrical survey of a country cannot be undertaken, nothing can be done but rough prismatic compass route mapping; for it is possible to produce a really good topographical map based on rapid triangulation and filled in by plane-tabling and traversing with considerable accuracy—so accurate, indeed, ought it to be that, drawn on the 1 : 250,000 scale, the error in position of any of the fixed points on the map should be unappreciable to the eye.

The following are the survey methods recommended to geographical surveyors:—

I.—*Determination of Fixed Points upon which the Map is to Depend*—

(1.) Triangulation with transit theodolite.

(2.) Latitude and Azimuth Traverses, with rounds of angles from stations on the route.

(3.) Latitudes and telegraphically or chronometrically determined longitudes, or differences of longitude, and occultations of stars. (This subject is dealt with separately in Part V.)

II.—*Filling in Detail between Fixed Points and Route Surveying*—

(1.) Plane table surveys and traverses.
(2.) Traversing with theodolite and secondary triangulation.
(3.) Subtense or tacheometer traverses.
(4.) Prismatic compass route traversing.
(5.) Photographic surveying.

III.—*Determination of Heights*—

(1.) Levelling and contouring.
(2.) Vertical angles with a theodolite.
(3.) Clinometer.
(4.) Mercurial barometer.
(5.) Boiling-point thermometer and aneroid.

In this part these subjects will be briefly dealt with in the order in which they are referred to above, but it must be remembered that this work does not profess to give more than hints, and those requiring fuller information should consult some of the standard works on surveying, of which a few are mentioned on p. 22.

I.—Determination of Fixed Points upon which the Map is to Depend.

The foundation of every survey is the base line, or the measured distance between two points in the region to be surveyed. The accuracy of the map will depend primarily upon the length of the base line, its relative position in reference to the points to be fixed from its ends, and the accuracy with which the line is measured. It is therefore necessary first of all to deal briefly with this subject.

Selection and Measurement of Base Line.—In any triangulation it is important that the length and position of the base line should be such that the angles measured with the theodolite from its ends are not too acute or too obtuse. A "well-conditioned" triangle should have

no angle greater than 90° nor less than 30°, but a slight excess on 90° is not so objectionable as a defect on 30°, as a small inaccuracy in the measurement of an acute angle may cause considerable error in the length of the sides deduced from it. The position of the line should, if possible, be somewhere near the centre of the country to be surveyed.

Before commencing a survey it is advisable to go over the country and make a rough sketch of it, selecting the most suitable position for the base line, and marking those points that will serve best for the primary stations of the triangulation. This will prove most useful and save time in the end.

It is important that the part of the country selected for the base line should be as level as possible, and that from each of the ends of the line a considerable number of distant points are visible.

Having selected the position of the base line, the next operation is to measure it, and this has to be done with great care, several times over, and a mean result taken. In important large-scale trigonometrical surveys, such as the Ordnance Survey of the British Isles and the Trigonometrical Survey of India, the measurement of a base line is a most elaborate and lengthy operation, and every care is taken to obtain the most accurate result, for which great refinement is necessary.

In a rapid geographical survey it frequently happens that all that can be done is to measure the base line several times over with a steel tape and take a mean; but recently "Invar," an alloy of steel and nickel, has been introduced, and a base-measuring apparatus has been constructed with an "Invar" tape. The coefficient of expansion owing to change of temperature in this, being only about $\frac{1}{200}$ that of ordinary steel, is sc slight that it may be neglected altogether. This tape is mentioned on p. 15. The Järderin wire apparatus has recently been used in the South African geodetic surveys with excellent results.

The following is a good example of an accurate measurement of a base line with a steel tape, giving also the method of comparison with standard, applying corrections for temperature, height above sea level, etc. It is taken from the 'Text Book of Topographical and Geographical Surveying':—

The base should be measured *at least once in each direction*, on a dull day, if possible, or in early morning or late afternoon.

Base Computations.—The measured length of the base is subject to five corrections :—

1. For *standard.*
2. ,, *temperature.*
3. ,, *inclination.*
4. ,, *sag.*
5. ,, *height above sea.*

The following case may be taken as an example :—

One tape was kept as a reference tape and not used for measuring. This, when tested at Southampton, had been found to be 0·05 feet short at 62° Fahr.

The base tape (supposed to be 100 feet long) used was 0·02 feet too long when compared with reference tape at 71° Fahr.

The temperature of base tape during measurement was 82° Fahr.

Length, as measured, 5301·24 feet.

Height of base line above sea 4,520 feet.

For 2300 feet, base had a slope of 1° 15′, remainder level.

1. *Standard* :—

Reference tape was 0·05 short at 62° Fahr.

Now steel expands ·00000625 of its length for 1° Fahr.

Therefore, at 71° it was $\frac{9 \times 100 \times 62 \cdot 5}{10{,}000{,}000}$ longer, or ·0056 feet longer.

Reference tape was therefore 0·0444 short at 71° Fahr.

Base ,, ,, 0·0200 long on reference tape at 71°.

,, ,, ,, 0·0244 short at 71° . . . . . . (*a*)

2. *Temperature* :—

Temperature of base tape during measurement was 82°, when compared was 71°.

Increase of length $\frac{11 \times 100 \times 62 \cdot 5}{10{,}000{,}000}$ or 0·0069 . . . . . . (*b*)

Subtracting (*b*) from (*a*), we find that the base tape during measurement was 0·0175 short; correction for standard and temperature is therefore

$$- \cdot 0175 \times \frac{5301}{100} = - 0 \cdot 928 \text{ feet.}$$

3. *Inclination* :—

For 2300 feet the base had a slope of $1° 15'$.

Correction $= - 2{,}300\ (1 - \cos 1° 15') = - 0{\cdot}550$.

4. *Sag* :—

In the measurement of a base it is desirable that the whole length of the tape should as far as possible be supported by the ground, so that no correction is necessary for the sag of the tape. Where the ground is uneven, it is customary to support the tape at intervals by pickets; but it may happen in the measurement of a base that a nullah or ravine has to be crossed. In such a case the sag, i.e., the difference between the length when suspended and the length when laid on a plane surface, must be determined and corrected for.

If s = the correction for sag,

l = the length of the tape suspended between two supports (in feet).

w = the weight of the tape in lbs.

t = the tension applied in lbs.

$s = l \dfrac{w^2}{24\ t^2}$ approximately.

5. *Height above sea* :—

All measurements are supposed to be made at sea-level. If the base is measured at a mean height h above sea-level, it will require a correction of $- \frac{h}{R} \times$ length of base, where R, the radius of the earth, may be taken as 20,900,000 feet.

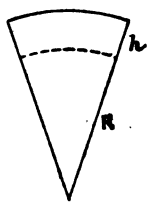


FIG. 37.

In this case $h = 4520$.

Then correction $= - \dfrac{4520 \times 5301}{20{,}900{,}000} = - 1{\cdot}146$.

Collecting these corrections:—

	Feet.
1 and 2. Standard and temperature . . .	$-0 \cdot 928$
3. Inclination	$-0 \cdot 550$
4. Sag	$-0 \cdot 000$
5. Height above sea	$-1 \cdot 146$
Total correction . . .	$-2 \cdot 624$
Measured length	$5301 \cdot 240$
Reduced length of base	$5298 \cdot 62$

It is clear that corrections 3 and 4 must always be negative; 1 and 2 may be either positive or negative.

As previously stated, it will frequently happen that time or circumstances will not admit of anything but a rough measurement with a steel tape, and when this is the case the following method of measuring the base line is recommended:—(1) Having selected the position of the base line, mark it out on the ground by poles or ranging-rods, which are kept in a straight line by means of the theodolite, placed at one end of the base. (2) Now, one man taking one end of the base line, and another the other, commence the actual measurement from the first station to the first 100 feet, keeping the line level by the theododite. The tape is kept at one tension by the spring attachment at the ends, and every effort made to prevent sag, by resting it upon supports. (3) Having thus measured the first distance, drop a "plumb-bob" from the end of the line, and placing a peg in at the position indicated,* commence the second measurement from this point, taking care to keep the tape properly in line, and level, by the theodolite.

This operation is repeated until the whole line is measured, and it is always well to go over the measurement several times. To prevent mistakes, the measurements between the different stages are noted in a book as they are taken.

* When time does not permit of this process, the distances between poles on the base line can be measured with the tape, and the angle of slope in each case read off the theodolite, allowance being made for the height of the theodolite. The horizontal distances can then be computed.

Every steel tape should be tested against a standard at a stated temperature before being taken abroad. Steel expands ·00000625 of its length for 1° Fahr. increase of temperature, and it is of course necessary in more exact measurements to apply a correction for this, as previously shown; but when the measurements have to be hurriedly made with the ordinary tape, with no special apparatus, it is not necessary to attempt this correction, as the error in actual measurement is likely to be far in excess of that caused by change of temperature.

If the angles of the triangulation are correctly measured, every error in the measurement of the base will be reproduced proportionally in the results of the triangulation. For instance, if the measurement makes the base $\frac{1}{500}$ longer than it really is, and the furthest point of the triangulation is really 500 miles distant from the base, the triangulation will place that point at a distance of 501 miles, or one mile too far.

If it is found impossible to measure a base line by chain or tape measurement, as is sometimes the case, especially in very mountainous regions, a fairly accurate one can be obtained by the tacheometer or subtense instrument, as explained on p. 151. Another method is to obtain an astronomical base by the latitude and azimuth method, as described on p. 117, but it is far better that a base should be actually measured whenever it is possible to do so. A base a mile long can generally be measured three times over, to give a mean value, in a day. During the progress of a survey it is advisable occasionally to measure check bases in order to detect any error that may have gradually accumulated during the progress of the work.

Extension of Base Line by Triangulation.—It frequently happens that the base line that can be actually measured is not long enough, or is not in a suitable position for the purposes of the survey to be undertaken, and it is then necessary to extend it by triangulation, which should be done in the manner shown on page 101.

In the following figure let A B be the measured base, and let it be required to obtain the distance G H, to serve as a base for starting the triangulation. Having carefully measured A B, as previously described, and set up suitable marks at all the stations A, B, C, D, E, F, G and H, with the theodolite at A, making a zero of B, measure the angles B A D and B A C, reading F. L. and F. R., and both micrometers or verniers of

the horizontal and vertical scales, not forgetting the level divisions. Repeat the measurement of the angles, if time permits, with another reading of the horizontal circle on the zero mark, about 30° from the first, and take a mean as the result, so as to correct for centering error of the instrument.*

Having taken all the angles at A, move the theodolite to B, and, making A zero, measure the angles A B C, D B A, as before described.

Next, with the theodolite at C, make a zero of D and measure the

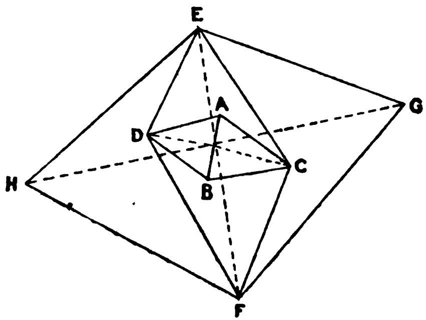


Fig. 38.

angles D C A, D C E, F C D and B C D. Then move the instrument to D, and with C made zero, measure the angles C D B, C D F, E D C and A D C.

Finally, with the theodolite placed at G and H, repeat the same

* In taking a round of angles it is always well to measure the angles right round the horizon, first from left to right and then from right to left. In both cases read F. L. and F. R., and, of course, both micrometers on each circle. When the object is accidentally passed it is better to unclamp the vernier-plate, bring it back beyond the object, reclamp, and make the intersection on the cross wires by turning the tangent-screw the *same way* as before. By this means if there is anything worn loose in the screws or fittings of the instrument, the correct difference of angle will still be measured. It is also always advisable to sight on to the ranging rods or flag-poles used as marks as near the ground as possible, as they may not be perfectly upright.

operation as before, at G with H zero, measuring the angles H G E and F G H, and at H, with G as zero, the angles G H F and E H G.

It is well also, as a check on the measurements at each station, after taking the angles as here described, to measure the whole angle at one sweep, for instance when the theodolite is at B, the angle D B C should be read.

With all the angles carefully observed and the distance A B measured, the distances C D, E F and G H can be computed by plane trigonometry (*see* p. 75), and thus a base line suitable in length and position for the triangulation obtained. It may not be necessary to make three extensions as shown here, as possibly the line E F would be long enough and in a suitable position to serve as a base, but this will depend upon circumstances. In any case, it is important that the angles should be well conditioned, that is, if possible not greater than 90° nor less than 30°, although a slight excess on 90° is not so objectionable as a defect on 30°.

This method of base extension has several advantages, and furnishes important checks. The lengths of the lines C D, E F and G H can be computed several times over and a mean taken, each computation being quite independent of the other, by using different angles and sides. For instance, the distance C D could be obtained by using the angles A B C and A B D with the sides C B and D B, and then again independently by the angles B A D and B A C, and the sides A C and A D. Similarly with the other distances, E F and G H.

The actual method of computation is that generally employed in computing triangulation, and consists of distributing the errors in the measurements of the angles and then computing the lengths of the sides by trigonometry, as shown in the next section. The latitude of at least one end of the extended base line, and its azimuth, must be obtained by astronomical observations, as shown in Part V.

Having obtained the correct length of the base line, its two ends are accurately marked upon the ground by the best means available (finally by burying a stone with a cross or triangle cut on it), and rounds of angles taken from each end to definite points or marks erected for the purpose, and the whole area to be surveyed divided up into a series of primary triangles; all the angles of which should be measured. It is important to remember that in all surveys the rule is to set out large

triangles first, and then, when the primary triangulation is complete, to subdivide these into smaller ones; or, in other words, always work from the whole to its parts.

It frequently happens that only two angles of a triangle are observed, in cases where their apices are formed by conspicuous natural or artificial objects, which will be useful as points of reference for detail surveys, but from which no triangulation will be carried further. Such points are called ***intersected points***, and in the triangles facing them angles between 15° and 150° may often be permissible, although, of course, angles about 60° would be much better. If possible, all intersected points should be fixed from at least three stations, as the third ray will be a check upon the intersection.

In running a chain of triangles from a measured base it is always preferable to construct a double series as the sides of all the triangles can then be computed by two independent methods by using different angles, thus furnishing a check upon the work. Fig. 39 shows a single series, and Fig. 40 a double series.

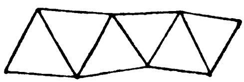


FIG. 39.

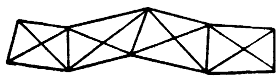


FIG. 40.

Computation of Triangulation.

In all plane triangles the sum of the three angles equals 180°, but since the sides of any geodetic triangle are measured on the spherical surface of the earth, strictly speaking the sum of the three angles slightly exceeds 180°. This ***spherical excess***, as it is called, is proportional to the area of the triangle, and must be always very small, amounting in the case of a triangle of 75·5 square miles to about 1″. It is therefore unnecessary to consider it unless the triangles are large, or the triangulation is to extend over a long distance.

The operation of computing the triangulation, treating the earth as a plane, is the following:—Add the three angles together, and take the difference between the sum and 180°. This will be the total error in the

measurement of the angles, and when an equal number of measurements of the angles have been made at each station, and there is no reason to suppose that the error is in one angle more than another, apply one-third of the total error to each of the angles by adding it or subtracting it, according to whether the sum of the three angles is less or greater than 180°.

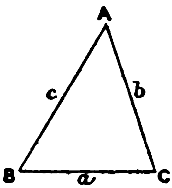


FIG. 41.

Let A B C be a triangle in a survey of which the length of the side c, and the angles A, B, and C are known, and it is required to find the sides a and b, then:

$$a = c\frac{\sin. A}{\sin. C}; \text{ and } b = c\frac{\sin. B}{\sin. C}.$$

As previously stated, for the purpose of a geographical survey, it is generally sufficiently accurate to distribute the angular error in the triangles equally throughout the angles; but at times when greater accuracy is required, the angles should be adjusted by some application of the method of least squares.

Reduction to the Centre.

It sometimes happens that angles are required from some point, such as a tree or steeple, where it is impossible to erect the theodolite, and in such cases it is set up at the nearest convenient point, called a satellite station, at a short distance from the object, and the angles taken from this station can afterwards be reduced to the true values at the object itself.

Suppose the triangulator has observed the trunk of a tree on the summit of a hill, and that on his arrival he finds it is impossible for him to observe with his theodolite nearer to the tree than several feet; he would put up his theodolite in the most convenient place, as near to the tree as possible, and observe his round of angles as usual, taking care to include the centre of the trunk of the tree. He must also measure accurately the distance from his station to the trunk of the tree. He can now correct his angles in either of the two ways:—

I. If a number of angles have been taken from the station, and only

two or three have been taken to the tree, and if it is possible to raise upon the station a mark sufficiently conspicuous to be observable from any future stations there may be, it is preferable to correct the two or three angles already taken to the tree to what they would have been had the station been observed instead of the tree.

II. If, on the other hand, only a few angles have been taken at the station, and if it is impossible to erect on it as useful a mark as the tree, then it is advisable to reduce the angles taken at the station to what they would have been had they been taken on the spot occupied by the tree. This is called reduction to the centre.

(I.) Let A B be two stations from which the tree T has been observed, and let S be the station or spot where the theodolite was set up. It is required to obtain the angles S A B and A B S, the angles T A B and A B T being known. From inspection it is evident that S A B = T A B + S A T. Now, in the triangle T S A, T S has been measured; the side T A can be computed from the triangle A B T, or it can be measured with sufficient accuracy from the triangulator's chart, and the angle T S A has been observed, and sin A : sin S : : S T : A T. From this proportion S A T can be obtained, and therefore S A B. In the same way A B S can be obtained.

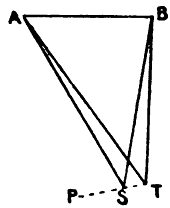


FIG. 42.

(II.) Produce T S to P; then the angle B S P = the interior and opposite angles B T S and S B T;

$\therefore$ BSA + ASP = BTA + ATS + SBT, and ASP = SAT + ATS;

$\therefore$ BTA + ATS + SBT = BSA + SAT + ATS;

$\therefore$ $BTA = BSA + SAT \dot{-} SBT$.

Obtain S A T and S B T as in (I.), and correct B S A to get B T A.

Interpolation, or Fixing the Observer's Position by means of Angles taken to known Points.

When three or more points in a survey have been accurately laid down, and the angles subtended by these points at the observer's position are known, it is possible for him to determine his position by several different methods. Graphically, by means of a station pointer, or as described

under the heading of Plane Table Surveying (pp. 127–134), or more accurately by computation by plane trigonometry, as follows :—

(*a*) Fixing the position of a point by angles taken from it to three previously fixed points; in this there are three cases as below.

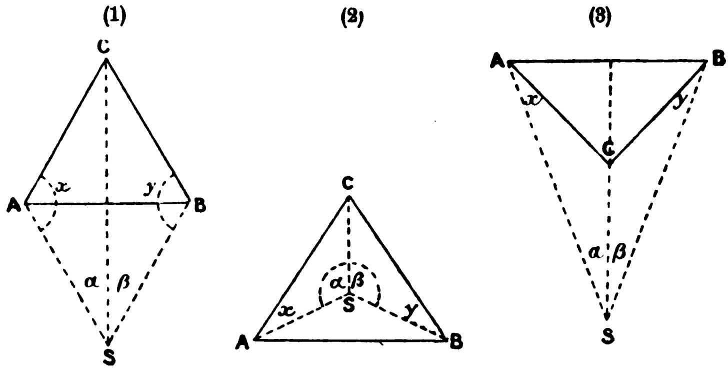


FIG. 43.

Let S be the observer's position, α and β observed angles, then

$$x + y = 360° - (\alpha + \beta + C) \text{ in (1) and (2)}$$
$$x + y = C - (\alpha + \beta) \text{ in (3)}$$

Let
$$\tan \phi = \frac{\sin \alpha}{\sin \beta} \times \frac{a}{b},$$

then
$$\tan \frac{x - y}{2} = \tan (\phi - 45°) \tan \frac{x + y}{2}$$

Having thus found half the sum and half the difference of x and y, the angles themselves are easily obtained; for half the sum *plus* half the difference equals the greater angle, and half the sum *minus* half the difference equals the lesser angle. Then with the angles and the sides A C and C B known, the lengths of the other sides can readily be computed.

In case (1) if S, A, B, C, are on the circumference of the same circle, the problem is insoluble.

(*b*) Fixing the position of two points by angles taken from them to two previously fixed points.

A and B are known points. The angles 2, 3, 4, 5 are observed; 1, 6 are deduced. Then, if

$$P = \frac{\sin 1 \sin 3 \sin 5}{\sin 2 \sin 4 \sin 6},$$

$$\tan \tfrac{1}{2}(y - x) = \tan \tfrac{1}{2}(3 + 4)\frac{1 - P}{1 + P}.$$

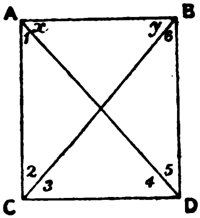


FIG. 44.

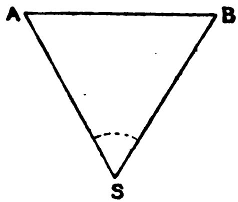


FIG. 45.

(c) Fixing the position of a point by angles from it to two known points and an azimuth.

Let A and B be two known points. At S observe the angle A S B and the azimuth of S A or S B (by the sun will do) as shown on p. 258.

Get some approximate value for the position of S from the plane-table, or by traverse.

Then compute reverse azimuths of A S and B S, as below.

$$d\,A = d\,L \sin \lambda,$$

where $d\,A$ = increment of azimuth in seconds,
$d\,L$ = difference of longitude in seconds of arc
λ = mean latitude.

The way to apply the quantity $d\,A$ can easily be seen by considering in which direction the meridians converge. Then, knowing the azimuths of A S, B S, and that of A B (which is a known line), the differences give the angles A and B, and in the triangle A S B we know the three angles and one side (A B).

Method (*a*) and method (*b*) are much strengthened if an azimuth is observed. The use of an azimuth enables two solutions to be found in each case, and a check is thus obtained. It is a general maxim in interpolation that azimuths should be observed when possible.

When the theodolite triangulation is completed, it becomes necessary to place the stations in their correct positions on a plane-table sheet for the purpose of filling in, or to prepare lists of their latitudes and longitudes. In rough route survey work, with prismatic compass, it is usual to plot by angles and distance by means of a circular protractor and scale of miles or yards, but this method is not close enough for exact work. It is impossible to set off the angles with sufficient accuracy, and errors rapidly accumulate. The positions of the stations in a triangulation should therefore be found by one of the following methods.

(1) *Computation of Geodetic Latitudes, Longitudes and Azimuths.*—For this method it is necessary to know the lengths of the sides of the triangles, or legs of the traverse, the latitude and longitude of the first station, A, and the azimuth or true bearing of the second from the first. In a chain of triangles the lengths of the sides can be obtained, as shown on p. 104. The latitude and azimuth can be determined, as shown in Part V., and if the longitude of the starting point is not accurately known, it can be assumed, as the differences will work out correctly, and it will only be necessary later on to apply a constant correction to all the positions. The following is an example of the computation:—

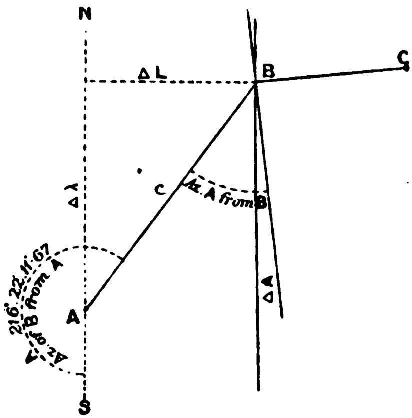


FIG. 46.

Data at Station A. Crawley Water Tower.

Latitude λ = 51° 6′ 33″·97

Longitude L = 11′ 48″ W.

Azimuth of A B = 36° 22′ 11″·67
[Measured from S. by W. = 216° 22′ 11·67″.]

Distance at Mean Sea Level between A and B
c = 37939·3 ft. log. c = 4·5790894.

Required at Station B. Outwood Mill.

Latitude, Longitude and Azimuth of A from B.

FORMULÆ.	CALCULATIONS. *Vide* Table XIII. for P.Q.R.S.T.		RESULTS. Signs obtained from Table (*a*) or (*b*).
	log P	$\bar{3}$·9940051	
$\delta_1 \lambda = \mathrm{P} \cos A\, \mathrm{c}$	log cos A	9·9059067	
	log c	4·5790894	
	log $\delta_1 \lambda$	2·4790012	$\delta_1 \lambda = +\ 301''·31$
$\delta_1 \mathrm{L} = \delta_1 \lambda\, \mathrm{Q} \sec \lambda \tan A$	log Q	$\bar{1}$·9988321	
	log sec λ	0·2021544	
	log tan A	9·8671451	
	log δ_1 L	2·5471328	$\delta_1 \mathrm{L} = +\ 352''·47$
$\delta_1 A = \delta_1 \mathrm{L} \sin \lambda$	log sin λ	9·8911730	
2nd Diffs. not required in computing small triangles of less than 1 mile sides.	log $\delta_1 A$	2·4383058	$\delta_1 A = +\ 274''·35$
$\delta_2 \lambda = \delta_1 A\, \mathrm{R} \sin A\, \mathrm{c}$	log R	$\bar{8}$·37856	
	log sin A	9·77305	
	log c	4·57908	
	log $\delta_2 \lambda$	$\bar{1}$·16900	$\delta_2 \lambda = -\ ·147''$
$\delta_2 \mathrm{L} = \delta_2 \lambda\, \mathrm{S}. \cot A$	log S.	0·50201	
	log cot A	0·13285	
	log δ_2 L	$\bar{1}$·80386	$\delta_2 \mathrm{L} = +\ ·636''$
$\delta_2 A = \delta_2 \mathrm{L}\, \mathrm{T}$	log T	0·01378	
	log $\delta_2 A$	$\bar{1}$·81764	$\delta_2 A = +\ ·657''$

Continued on p. 110.

Continuation from p. 109.

FORMULÆ.	CALCULATIONS. *Vide* Table XIII. for P.Q.R.S.T.					RESULTS. Signs obtained from Table (*a*) or (*b*).
			°	′	″	
Lat. of B $= \lambda + \Delta\lambda$	λ		51	6	33·97	
$\Delta\lambda = \delta_1\lambda + \delta_2\lambda$	$\delta_1\lambda$	+		5	1·31	
	$\delta_2\lambda$	−			·15	
			51	11	35·13	= Latitude of B.
Long. of B $= L + \Delta L$						
$^*\Delta L = \delta_1 L + \delta_2 L$	L	−		11	48	
When A is W. of Greenwich	$^*\delta_1 L$	+		5	52·47	
the sign of ΔL must be	$^*\delta_2 L$	+			·64	
changed before applying it to L		−		5	54·89W	= Longitude of B.
	$\pi + A$ (396° 22′ 11·67″ − 360°)					
Az. of A from B $= \pi + A + \Delta A$		=	36	22	11·67	
$\Delta A = \delta_1 A + \delta_2 A$	$\delta_1 A$	+		4	34·40	
	$\delta_2 A$	+			·66	
			36	26	46·73	= Azimuth of A from B.

The quantities P, Q, R, S, T are found in Table XIII. and are taken out for the known latitude. The rules for the signs of the differences of λ, L, and A are given on the following tables:—

Directions for applying the signs to the terms of the Latitude, Longitude, and Azimuth Formulæ, when the *fixed* station A lies *North* of the equator.

The Azimuth is reckoned from South by West. The Latitude North, and Longitude East, should always be considered *positive*.

TERMS OF THE FORMULÆ.	TABLE (*a*).—MAGNITUDE OF THE GIVEN AZIMUTH A.			
	0° to 90°	90° to 180°	180° to 270°	270° to 360°
$\delta_1\lambda$	−	+	+	−
$\delta_1 L$	−	−	+	+
$\delta_1 A$	−	−	+	+
$\delta_2\lambda$	−	−	−	−
$\delta_2 L$	+	−	+	−
$\delta_2 A$	+	−	+	−

For use in Distance and Azimuth computation :—

$A + \frac{\Delta A}{2}$ is in	1st	2nd	3rd	4th quadrant
when $\frac{\Delta \lambda}{\Delta L}$ are	$\frac{-}{-}$	$\frac{+}{-}$	$\frac{+}{+}$	$\frac{-}{+}$

Directions for applying the signs to the terms of the Latitude, Longitude, and Azimuth Formulæ, when the *fixed* station A lies to the *South* of the equator :—

The Latitude South, and the Longitude East, should be considered positive.

TERMS OF THE FORMULÆ.	TABLE (*b*).—MAGNITUDE OF THE GIVEN AZIMUTH A.			
	0° to 90°	90° to 180°	180° to 270°	270° to 360°
$\delta_1\lambda$	+	−	−	+
$\delta_1 L$	−	−	+	+
$\delta_1 A$	+	+	−	−
$\delta_2\lambda$	−	−	−	−
$\delta_2 L$	−	+	−	+
$\delta_2 A$	+	−	+	−

For use in Distance and Azimuth computation :—

$A + \frac{\Delta A}{2}$ is in	1st	2nd	3rd	4th quadrant
when $\frac{\Delta \lambda}{\Delta L}$ are	$\frac{+}{-}$	$\frac{-}{-}$	$\frac{-}{+}$	$\frac{+}{+}$

Explanation and Use of above Sign Tables.

$$\Delta \lambda = \delta_1 \lambda + \delta_2 \lambda$$
$$\Delta L = \delta_1 L + \delta_2 L$$
$$\Delta A = \delta_1 A + \delta_2 A$$

Computation of Latitude, Longitude and Azimuth (Form p. 109).

λ_b	When $\Delta\,\lambda$ comes out negative and greater than the latitude of station A, the difference is the latitude of the deduced station B on the other side of the equator.
$L \pm \Delta\,L$	When station A is west of Greenwich the sign of L is negative.

Computation of Distances and Azimuths (Form p. 116).

Sign of $\Delta\,\lambda$	When A and B are both north or both south of the equator $\Delta\,\lambda$ is $\frac{+}{-}$ when latitude of B is $\frac{\text{greater}}{\text{less}}$ than latitude of A. If the ray crosses the equator the *sum* of the latitudes should be taken for $\Delta\,\lambda$, and is *always negative.*
Sign of $\Delta\,L$	When the longitudes of both A and B are west, $\Delta\,L$ is $\frac{+}{-}$ when the longitude of B is $\frac{\text{less}}{\text{greater}}$ than the longitude of A. When the longitudes of both A and B are east, $\Delta\,L$ is $\frac{+}{-}$ when the longitude of B is $\frac{\text{greater}}{\text{less}}$ than the longitude of A. When the ray crosses the meridian of Greenwich, the sum of the longitudes is to be taken for $\Delta\,L$, and it is $\frac{+}{-}$ if B is $\frac{\text{east}}{\text{west}}$ of Greenwich.
Middle Latitude λ_m	When A and B are both on one side of the equator, the middle latitude is half the sum of the latitudes; and when on opposite sides it is half their difference.
Sign of $\Delta\,A$	When the middle latitude is $\frac{\text{north}}{\text{south}}$ of the equator $\Delta\,A$ has the $\frac{\text{same}}{\text{opposite}}$ sign as $\Delta\,L$.
Quadrant of $A + \frac{\Delta\,A}{2}$	The quadrant is determined by the information at bottom of the preceding tables (p. 111).

Having computed the latitude and longitude of B, as shown on pp. 119, 110, and the azimuth of A from B, the position of the next station C (Fig. 46) can be obtained, since the length of B C, another side in the triangulation or measured length of a traverse, and the angle A B C are known. The azimuth of C will, in this case, be the angle A B C − A z of A from B, or reckoning from the south point, as is done in this computation, 360° − (A B C − A z of A from B). In the same manner the latitude and longitude of any of the stations in the triangulation or traverse can be obtained, although it is well occasionally to take fresh observations for latitude and azimuth, as a check.

This is the method of computing the positions of stations when they are required to be accurately known, or are likely to be used later on for continuing the survey. When the sides of the triangles are long, or the total distance of the triangulation is likely to exceed 200 miles, it should always be adopted.

Having obtained the latitudes and longitudes of the stations on a survey, they can be laid down accurately on a projection (constructed as shown on p. 90) for filling in by plane table, or a table of positions can be constructed.

(2) *Rectangular Co-ordinates.*—Another method of plotting the positions of stations is by rectangular co-ordinates, and this can be

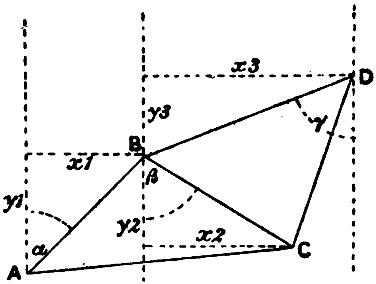


FIG. 47.

employed when there is no probability of the further stations being used to continue the survey, and the distances are not great.

In this method, as before, the position of A is assumed to be known, the sides of the triangles are supposed to have been computed, or in the case of a traverse to have been measured, and the azimuth of B from A (the angle a) known from an astronomical observation (*see* p. 258). Then proceed as follows:—

Select A as the initial station and the meridian through that station as the initial meridian, then, treating the earth's surface as a plane, calculate the *co-ordinates* of all the stations, the co-ordinates being measured along and at right angles to the initial meridian, thus:—

If a is the azimuth of the first side A B, A the initial point, then x_1 (the co-ordinate at right angles to the meridian)

$$\begin{aligned} &= \text{A B} \sin a \\ y_1 &= \text{A B} \cos a \\ \left.\begin{aligned} x_2 &= \text{B C} \sin \beta \\ y_2 &= \text{B C} \cos \beta \end{aligned}\right\} & \text{ where } \beta = \text{A B C} - a. \end{aligned}$$

Then the co-ordinates of A are	o		o	
,,	,,	B ,,	x_1	y_1
,,	,,	C ,,	$x_1 + x_2$,	$y_1 - y_2$, &c.

All these points can now be plotted with reference to the initial point A, and its meridian, the distances being taken from a diagonal scale of miles or feet.

It is important to note that once the initial meridian has been left, the angles β, γ, &c., formed by the sides with the lines parallel to the meridian, are no longer the true bearings of these lines, and should never be used as such.

It is clear that if a chain of triangles runs in an oblique direction, it may be convenient to plot along and at right angles to a line of known bearing running generally in the same direction.

When the latitudes and longitudes of two stations are accurately known, the distance between them, and their azimuths can be computed as follows:—

COMPUTATION OF DISTANCES AND AZIMUTHS.

Required.	**Azimuths B from A (A) and A from B ($\pi + A + \Delta A$), and length in feet between Station A and Station B (c).**

DATA.		LATITUDE.	LONGITUDE.
Station A.	Beacon Hill	$\lambda_a = 51^\circ\ 4'\ 59''$ N.	$L_a = 0^\circ\ 14'\ 54''$ W.
Station B.	Pilgrim's Way	$\lambda_b = 51\ \ 15\ \ 3$ N.	$L_b = 0\ \ 12\ \ 34$ W.
		$\therefore \Delta\lambda = \pm\ 10'\ 4''$	$\therefore \Delta L = \pm\ 2'\ 20''$
		$\frac{\Delta\lambda}{2} = \pm\ 5\ \ 2$	$\frac{\Delta L}{2} = \pm\ 1\ \ 10$
λ_m = Middle Latitude $\left(\lambda_a + \frac{\Delta\lambda}{2}\right)$		$= 51^\circ\ 10'\ 1''$	

$\Delta\lambda$ When A and B are both north or south of the Equator:

$\Delta\lambda$ is $\frac{+}{-}$ when λ_b is $\frac{\text{greater}}{\text{less}}$ than λ_a, and $\lambda_m = \frac{1}{2}(\lambda_a + \lambda_b)$.

If the ray crosses the Equator:

$\Delta\lambda$ is always negative and $= \lambda_a + \lambda_b$, and $\lambda_m = \frac{1}{2}$ diff. between λ_a and λ_b.

ΔL When A and B are both west of Greenwich:

ΔL is $\frac{+}{-}$ when L_b is $\frac{\text{less}}{\text{greater}}$ than L_a.

When A and B are both east of Greenwich:

ΔL is $\frac{+}{-}$ when L_b is $\frac{\text{greater}}{\text{less}}$ than L_a.

If the ray crosses the meridian of Greenwich:

$\Delta L = L_a + L_b$ and is $\frac{+}{-}$ if L_b is $\frac{\text{E}}{\text{W}}$ of Greenwich.

FORMULÆ.	LOGARITHMS.	RESULTS.
$\frac{\Delta A}{2} = \frac{\Delta \mathrm{L}}{2} \sin \lambda_m$	$\log \frac{\Delta \mathrm{L}}{2}$ (in secs.) $= 1 \cdot 845098$ $\log \sin \lambda_m = 9 \cdot 891525$ $\log \frac{\Delta A}{2} = 1 \cdot 736623$	$\frac{\Delta A}{2} = 54'' \cdot 53$ [When λ_m is North/South of equator ΔA has the same/opposite sign as Δ L.]
$\log \tan \left(A + \frac{\Delta A}{2}\right)$ $=$ log Table XV.* $-$ log Table XIV.* $+ \log \Delta \mathrm{L} - \log \Delta \lambda$	log Table XV. $= 1 \cdot 804469$ Co-log Table XIV. $= 7 \cdot 994001$ $\log \Delta$ L (in secs.) $= 2 \cdot 146128$ Co-log $\Delta \lambda = 7 \cdot 218963$ $\log \tan \left(A + \frac{\Delta A}{2}\right) = 9 \cdot 163561$	$A + \frac{\Delta A}{2} = 8^\circ\ 17'\ 29'' \cdot 7$ [Quadrant obtained from Table (*a*) or (*b*) (p. 111) with given signs of $\Delta \lambda$ and Δ L as above.]
$\log c$ $= \log \sec \left(A + \frac{\Delta A}{2}\right)$ $+$ log Table XIV.* $+ \log \Delta \lambda$	$\log \sec \left(A + \frac{\Delta A}{2}\right) = 0 \cdot 004563$ log Table XIV. $= 2 \cdot 006000$ $\log \Delta \lambda$ (in secs.) $= 2 \cdot 781037$ $\log c = 4 \cdot 791600$	$c = 61887$ ft. ($= 11 \cdot 72$ miles)
Required Azimuths.		
A	$A + \frac{\Delta A}{2} = 188^\circ\ 17'\ 29'' \cdot 70$ $\frac{\Delta A}{2} = (+ \text{ or } -) - \quad 54 \cdot 53$†	
	Diff. $= 188\ \ 16\ \ 35 \cdot 17$	= (A) Azimuth of B from A.
$\pi + A + \Delta A$	$\pi +$ Sum $= 8\ \ 18\ \ 24 \cdot 23$	= (B) Azimuth of A from B.

* Values for middle latitude, *i.e.*, for $\lambda + \frac{\Delta \lambda}{2}$

† The sign of $\frac{\Delta A}{2}$ is the same as that of the Δ L, and according to the rule on page 111 it is +, but since West Longitude is $-$ it is here subtracted, as it is the algebraic sum,

Latitude and Azimuth Traverse, and Astronomical Base.

It frequently happens that want of time or other circumstances do not permit of carrying on a systematic triangulation through a country, and the surveyor must have recourse to some more rapid method of operation. When this is the case he cannot do better than attempt to carry on a Latitude and Azimuth Traverse. It is necessary, however, to bear in mind that this system is impossible when the route runs east and west, and when it approximates to this direction the results are quite unreliable. The most satisfactory results may be expected when the route follows a direction not more than 30° from the N. or S. points, although from 30° to 45° will sometimes answer fairly well if the astronomical observations are good.

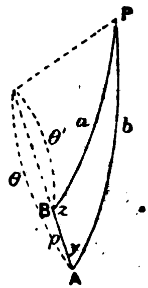


FIG. 48.

In Fig. 48 let A and B be two stations of which the latitudes have been determined by astronomical observations, and let y be the azimuth of B from A. It is required to obtain the difference of longitude P and the distance p between the two stations.

a and b will be the co-latitudes of the stations A and B, but since these are the geographical co-latitudes and the computation is to be performed by spherical formulæ, it is first necessary to correct these sides, which is done as follows:—Look out the natural number corresponding to log C in the table on p. 120, and put

$$x = \frac{d}{2} \cdot \frac{C - 1}{C}$$

where x = the required correction, d the difference of the latitudes, and C a quantity taken from the table.

Then
$$a = 90° - \text{lat. B} + x$$
$$b = 90° - \text{lat. A} - x$$

The next operation is to find the distance p between the stations, as follows:—

$$\tan \theta = \tan b \cos y \quad . \quad . \quad . \quad \text{(I.)}$$

$$\cos \theta' = \frac{\cos \theta \cos a}{\cos b} \quad . \quad . \quad . \quad \text{(II.)}$$

Then $$p \text{ (the distance)} = \theta - \theta' \quad . \quad . \quad . \quad \text{(III.)}$$

and $$\sin P \text{ (diff. long.)} = \sin p \frac{\sin y}{\sin a} \quad . \quad . \quad \text{(IV.)}$$

This distance p, converted into feet by the table on p. 119, can be used as an astronomical base for the survey, and if, when at A, B is made zero, and a round of angles taken to distant points, and again, when at B, A is made zero and another round of angles taken to the same points, the position of these points may be computed as previously described (pp. 80 or 103).

It frequently happens that the back azimuth, z, is alone observed, in which case the formulæ are altered by substituting b for a, and a for b, in (I.), (II.), and (IV.).

It is evident that this operation can be repeated as often as required when the direction of the route is suitable and good points can be found, and Latitude and Azimuth Traverses of this kind have been, under favourable circumstances, carried across regions with great rapidity and remarkable accuracy.

The accuracy must, of course, depend upon that of the latitudes and azimuths observed, and, as has been stated, upon the direction followed. This method should never be used for short distances, but for long ones, provided the stations can be clearly seen, it possesses certain advantages, the chief being that the errors do not increase with the distance; for supposing an error in latitude of 2″ to exist in the observations for latitude, no greater error than this is likely to occur whether the distance between the stations is ten miles or forty miles. It is, of course, understood that a measured base is always to be preferred to one depending upon astronomical observations.

It will sometimes happen that after carrying on a Latitude and Azimuth Traverse for some distance the route turns east and west, in which case the method has to be abandoned unless the difficulty can be overcome by taking a zig-zag course. If this cannot be done, the best way is to measure a base and carry on a triangulation until the traverse system can again be taken up.

Distance in Feet for this Computation.*

Lat.	10,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	90,000
°	″	″	″	″	″	″	″	″	″
0	98·57	197·13	295·70	394·27	492·84	591·40	689·97	788·54	887·10
2	·57	·13	·70	·27	·83	·40	·97	·53	·10
4	·57	·13	·70	·26	·83	·39	·96	·52	·09
6	·56	·13	·69	·25	·82	·38	·94	·51	·07
8	·56	·12	·68	·24	·80	·36	·92	·48	·04
10	·56	·11	·67	·23	·78	·34	·90	·46	·01
12	·55	·10	·66	·21	·76	·32	·87	·42	886·97
14	·55	·09	·64	·19	·74	·28	·83	·38	·93
16	·54	·08	·62	·17	·71	·25	·79	·33	·87
18	·54	·07	·60	·14	·68	·21	·75	·28	·82
20	·53	·06	·58	·11	·64	·17	·70	·22	·75
22	·52	·04	·56	·08	·60	·12	·64	·16	·68
24	·51	·02	·54	·04	·56	·07	·58	·09	·61
26	·50	·01	·51	·01	·51	·02	·52	·02	·52
28	·49	196·99	·48	393·97	·47	590·96	·45	787·95	·44
30	·48	·97	·45	·93	·42	·90	·38	·87	·35
32	·47	·95	·42	·89	·37	·84	·31	·78	·26
34	·46	·92	·39	·85	·31	·77	·24	·70	·16
36	·45	·90	·35	·81	·26	·71	·16	·61	·06
38	·44	·88	·32	·76	·20	·64	·08	·52	885·96
40	·43	·86	·29	·72	·14	·57	·00	·43	·86
42	·42	·83	·25	·67	·09	·50	688·92	·34	·75
44	·41	·81	·22	·62	·03	·43	·84	·24	·65
46	·39	·79	·18	·58	491·97	·36	·76	·15	·54
48	·38	·76	·15	·53	·91	·29	·68	·06	·44
50	·37	·74	·11	·48	·85	·22	·59	786·96	·34
52	·36	·72	·08	·44	·79	·15	·51	·86	·23
54	·35	·70	·04	·39	·74	·09	·44	·78	·13
56	·34	·67	·01	·35	·68	·02	·36	·70	·03
58	·33	·65	294·98	·30	·63	589·96	·28	·61	884·94
60	·32	·63	·95	·26	·58	·90	·21	·53	·84

* Computed from formula :—

Number of seconds in arc $= \dfrac{\text{length in feet} \times 180 \times 3{,}600}{\pi\nu}$ where $\nu =$ normal to the meridian terminated by the minor axis.

Example :—What is the value in arc of 67,542 feet on the equator?

	Feet.	
Value for	60,000 =	591·400
	7,000	68·997
	500	4·928
	40	·394
	2	·020
	67,542 =	665·740 seconds.

Logarithms of constant C* for obtaining true difference of latitude.

Lat.	Log C.	Lat.	Log C.	Lat.	Log C.
0	·0029568				
1	9559	21	·0025782	41	·0016866
2	9532	22	5431	42	6354
3	9487	23	5067	43	5840
4	9425	24	4690	44	5325
5	9344	25	4302	45	4809
6	·0029246	26	3902	46	·0014293
7	9130	27	3490	47	3778
8	8997	28	3068	48	3264
9	8847	29	2636	49	2751
10	8679	30	2195	50	2241
11	·0028495	31	·0021744	51	·0011734
12	8294	32	1285	52	1231
13	8077	33	0818	53	0732
14	7843	34	0344	54	0238
15	7595	35	·0019863	55	·0009750
16	·0027329	36	9375	56	9267
17	7048	37	8882	57	8792
18	6753	38	8384	58	8323
19	6444	39	7882	59	7863
20	6120	40	7375	60	7411

* Computed from formula :—

$$C = \frac{\text{normal to meridian}}{\text{radius of curvature of meridian.}}$$

Example :—The difference of latitude between two stations (mean latitude, 10° north) calculated by spherical formulæ is 1156″·72. What is the true difference?

$$\log 1156 \cdot 72 = 3 \cdot 0632282$$
$$\log C \text{ (above)} = 0 \cdot 0028679$$
$$\overline{\quad 3 \cdot 0660961 \quad}$$

True difference of latitude = 1164″·38.

Example of Latitude and Azimuth Traverse.

$$\begin{array}{rrrr} \text{Lat. B} = & 51^\circ & 15' & 2''57 \\ \text{A} = & 51 & 4 & 59\cdot52 \\ \hline d = & & 10 & 8\cdot05 \\ = & & & 603\cdot05 \end{array}$$

$$x = \frac{d}{2} \cdot \frac{C-1}{C}$$
$$b = 90 - \lambda\,A - x$$
$$a = 90 - \lambda\,B + x$$

$$x = \frac{603\cdot05}{2} \times \frac{1\cdot0027 - 1}{1\cdot0027}$$

$$\text{Log } x = \log 2\cdot479316 + \log \bar{3}\cdot431364 - \log \cdot001171$$

$$\begin{array}{r} 2\cdot479316 \\ \bar{3}\cdot431364 \\ \hline \bar{1}\cdot910680 \\ \cdot001160 \\ \hline \bar{1}\cdot909520 \end{array} \ldots \log x = \cdot81''$$

$$\begin{array}{rrrr} \therefore & 90^\circ & 0' & 0'' \\ \text{Lat. B} & 51 & 15 & 2\cdot57 \\ \hline & 38 & 44 & 57\cdot43 \\ & & & +\ \cdot81 \\ \hline a = & 38 & 44 & 58\cdot24 \end{array} \qquad \begin{array}{rrrr} & 90^\circ & 0' & 0'' \\ \text{Lat. A} & 51 & 4 & 59\cdot52 \\ \hline & 38 & 55 & 0\cdot48 \\ & & & -\ \cdot81 \\ \hline b = & 38 & 54 & 59\cdot67 \end{array}$$

(*b*)

$$\text{Log tan } \theta = \tan 38^\circ\ 54'\ 59''67 + \log \cos 8^\circ\ 9'\ 48''62\ (y)$$

$$\begin{array}{r} 9\cdot907076 \\ 9\cdot995577 \\ \hline \end{array}$$

$$\text{log tan } 9\cdot902653 = 38^\circ\ 37'\ 54'' = \theta$$

$$\text{Log}\cos\theta' = \overset{(a)}{38\ 44\ 58\cdot24} + \log\cos \overset{(\theta)}{88\ 37'\ 54''} - \log\cos \overset{(b)}{38\ 54\ 59\cdot67}$$

$$\begin{array}{r}
9\cdot892033 \\
9\cdot892749 \\
\hline
9\cdot784782 \\
9\cdot891014 \\
\hline
\end{array}$$

$$\log\cos \underline{9\cdot893768} = \underline{38^\circ\ 27'\ 46''\cdot4\ (\theta')}$$

$$\begin{array}{rrrl}
\theta = & 88^\circ & 37' & 54'' \\
\theta' = & 88 & 27 & 46\cdot4 \\
\hline
p = & & 10 & 7\cdot6 = \underline{61{,}769\cdot1 \text{ ft.}} \text{ (by table on p. 119.)}
\end{array}$$

$$\text{Log}\sin P = \log\sin 10'\ 7''\cdot6 + \log\sin 8^\circ\ 9'\ 48''\cdot62 - \log\sin 38^\circ\ 44'\ 58''\cdot24$$

$$\begin{array}{r}
7\cdot469192 \\
9\cdot152284 \\
\hline
6\cdot621476 \\
9\cdot796517 \\
\hline
\end{array}$$

$$\log\sin \underline{6\cdot824959} = \underline{2'\ 17''\cdot84}\ P.$$

Another method of computing the distance in feet and difference in longitude of a Latitude and Azimuth Traverse is that shown below. This method, however, requires the use of Table XIII., and it is also necessary that the approximate difference of longitude should be known. The example is the same as that given above.

Computation.—Let A and B be two stations at which Latitudes have been observed, and at A the Azimuth of A B has been determined.

Let the difference of the two Latitudes = $\Delta\,\lambda$.

„ the Azimuth of A B at A = Az.

It is required to find (i.) the length of the line A B = c; (ii.) the difference of longitude of A and B in seconds of arc = Δ L.

Let the Azimuth at the middle point of A B = Az + $\dfrac{\Delta\ \text{Az}}{2} = a$

„ the mean Latitude of A and B = λ_m.

Let the difference of longitude determined approximately from a plane table sketch or any other means = $\Delta' L$

$$\frac{\Delta \text{ Az}}{2} = \frac{\Delta' L}{2} \sin \lambda_m \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Now apply this value of $\frac{\Delta \text{ Az}}{2}$ to Az (remembering in which way the meridians converge), and thus obtain a.

Then for the required difference of longitude,

$$\Delta L = \frac{\rho}{\nu} \tan a \sec \lambda_m \; . \; \Delta \lambda \quad . \quad . \quad . \quad (2)$$

where $\log \frac{\rho}{\nu}$ is the value of Q in table XIII. for mean latitude.

Also, for the length A B,

$$c = \Delta \lambda \; . \; \sec a \; . \; \rho \sin 1'' \quad . \quad . \quad . \quad . \quad (3)$$

where $\log \rho \sin 1''$ is the arithmetical complement of P in table XIII. for mean latitude.

$\Delta' L = 2' \; 10''$ Lat. A $51^\circ \; 4' \; 59''\!\cdot\!52$ $\lambda_m \; 51^\circ \; 10' \; 1''\!\cdot\!04$

                   ,, B 51 15 2 57

Azimuth of B from A = $8^\circ \; 9' \; 48''\!\cdot\!62$ = Az

$\frac{\Delta' L}{2} = 65'$	log	1·812913
Log sin λ_m = (51° $10'$ $1''\!\cdot\!04$) =		9·891524
$\frac{\Delta \text{ Az}}{2} = 50''\!\cdot\!634$ . . .	log	1·704437

Az =	8°	$9'$	$48''\!\cdot\!62$
$\frac{\Delta \text{ Az}}{2}$		+	50·63
a =	8	10	39·25

Log Q (table XIII.) . .		$\bar{1}$·996835
Log tan a	=	9·157461
Log sec λ_m	=	0·202696
$\Delta \lambda$ 603"	= log	2·780317
Δ L $137''\!\cdot\!82$	= log	2·139309

$\Delta \lambda$	log	2·780317
Log sec a		0·004438
Ar. Co. Log P (table XIII.).		2·005999
c 61,766 feet	= log	4·790754

II.—Filling in Detail between Fixed Points, and Route Surveying.

(1.) *Plane Table Surveying.* (*For description of this instrument, see p.* 55.)

In the previous chapter the methods of fixing the principal points in a survey by triangulation have been dealt with, and now it remains to show how the topographical detail can be filled in. For this purpose the instrument best suited to the geographical surveyor is, except in flat or forest-clad country, a plane table, such as that described on p. 55. The simpler the form of plane table the better, but it is a great advantage to have a light telescope with cross wires on the alidade, and a small vertical circle, instead of the ordinary sights. For mountain work very light plane tables have been constructed, and with practice and experience fairly accurate work can be done with them; even with a small military sketching board, such as Verner's, better results can be obtained than might be supposed, and these small instruments are very useful for rapid route surveying when time does not permit of doing more accurate work.

Having constructed a projection for his plane table sheet, as described on p. 89, and plotted the fixed points, as shown in the preceding section, the plane tabler commences to fix other points and fill in the topographical features. It should be remembered that the magnetic needle is liable to be deflected by local attraction, and therefore should not be relied upon more than can be helped; but it is used in the method of orienting, explained on p. 127, and for traversing, although in the latter it is better to verify by back and forward sighting. The needle is also useful at times for finding the surveyor's position on the board, when only two fixed points are available.

When no fixed points are available the plane tabler must commence an independent survey, and the first thing he has to decide on is the direction and extent of his base; and, as no special instructions can be given for a base suitable for all surveys, it is a matter in which he must exercise his own discretion, bearing in mind the following points: that the length of the base line should not be out of proportion to the distance of the points to be fixed, and that the first points to be fixed must be visible from both ends of the base line. The length of the base

should be accurately measured. Its direction must depend on the positions of the points to be fixed, as, when the angles subtended are either too obtuse or too acute, a small error in the alignment will produce a large one in the survey.

Having decided on a base line, call it A B (Fig. 49), set up the plane table over A, and arrange the board so that the direction of *a b* will suit the position of the first portion of the survey. Level it by moving the legs of the tripod and using the circular level on the ruler. Clamp the table, and mark a point on the paper in any convenient position to represent A on the ground; call this *a*. Place the fiducial edge of the ruler against point *a*, turn the ruler about until the other end of the

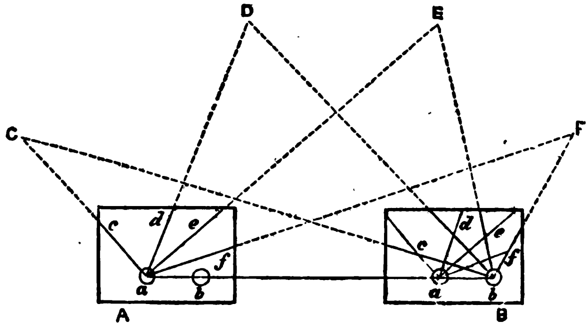


FIG. 49.

base, B, can be seen through the slit on one of the alidade sights, on the wire of the other sight, then draw a line along the fiducial edge from *a* towards *b*, and take the distance from A to B with the compasses from the scale on which it has been decided to construct the map; set it off on the line just drawn, and mark the end *b;* then *a b* on the board will represent the base line A B on the ground. Now set the sights in turn on the other points it is desired to fix, and, keeping the fiducial edge of the ruler against *a*, draw faint lines to each of them. To prevent mistakes, these lines, called "rays," should be marked with reference numbers indicating the object to which they are drawn, or the name of each object should be written against the line drawn to it. Having done this, place the compass on the table and turn

it about until the needle points exactly to the centre mark in the compass box, which will be magnetic north, then draw a dark line upon the paper, along the edge of the compass box, which can be afterwards used for orienting the table as explained (p. 135).

Having drawn all the rays at station A, remove the table to station B, set it up and level it in the manner before described. Place the fiducial edge of the ruler against *b*, and against *a*. Unclamp the table and turn it about until the sights are directed on A, then clamp the table, and it will be in a position to continue the work. The process of pivoting the ruler against the pin, and directing the sights on the objects to be fixed, is to be repeated precisely in the same manner as at station A, and the points where the rays drawn from *b* intersect the rays drawn from *a* will be the position of each object on the map. Fig. 49 illustrates the manner in which the work is done.

To continue the survey by obtaining fresh rays to objects from another station.—First orient the table correctly and find the position of that station on the board.

By *orienting* is meant placing the table in such a position that the north and south line on it shall correspond with the magnetic north and south; or, what is the same thing, so that the line drawn between any two stations on the board shall be parallel to the line between the stations on the ground.

The position on the board of the station at which the board is set up can be found, and the board oriented in a variety of ways.

(1.) *When the station has been fixed by two rays from the ends of the base or from other stations*, all that has to be done is to lay the fiducial edge of the ruler against the station mark, and against the mark on the board indicating the most distant station from which a ray has been drawn, turn the board until the sights are in a line with A, and clamp the board, which is then oriented.

(2.) *To find the position when only one ray has been drawn to the station.*—Set up the table over the station to be fixed, say D (Fig. 49, p. 125), and placing the fiducial edge of the ruler along the ray that has been drawn, say *a*, *d*, turn the table until the sights align on A, clamp the table, which will then be oriented. Place the alidade at *b* on the table and turn it about until it is aligned on B, and draw a line which will intersect the line already drawn at *d* on the table, the position required.

Repeating the last operation with other fixed stations will, if the lincs intersect, give certainty to the new position.

It may be mentioned that it is always preferable to choose a station which has one ray already drawn to it, to fixing by any of the following methods.

(3.) *To find the position when no ray has been drawn to it, but with three fixed points on the board*, the following methods may be employed.

With three visible stations, A B C (Figs. 52, 53, 55), represented on the table by *a b c*, the table can be oriented, and the position of an unknown point found.

*First Method.**—Set up the plane-table at the desired spot, fixing it as

* The following explanation will help to make the reason for these rules clear :—(I.) When the observer is inside the triangle formed by rays connecting the three objects. Let A B C (Fig. 50) be three points in nature, and *a b c* their

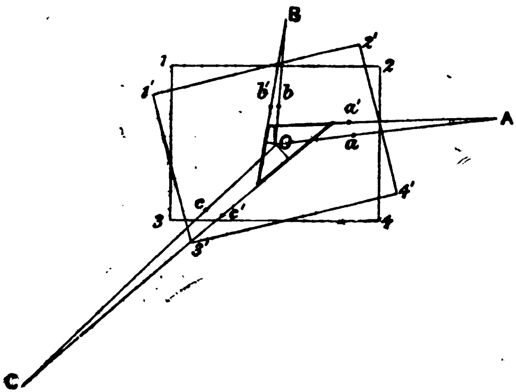


FIG. 50.

corresponding points on the plane-table, and let the observer be at O. Then suppose 1 2 3 4 to be the plane-table when properly oriented, in which case the rays to the three objects will all meet at O, and let 1′ 2′ 3′ 4′ be the table out of orientation, when the points *a b c*, representing the points on the

level as possible. The compass should then be placed accurately on the line previously drawn to indicate its position, as before described, and the plane-table turned round in azimuth until the needle points to 0°, and then clamped.

Three fixed points should then be selected from which to interpolate the position. The points should not be too distant, and if possible chosen so that the observer is inside the triangle formed by joining the three points. The ruler is then laid on each point in succession and lines drawn along its edge. If the plane-table has been set up accurately in azimuth, the

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plane-table, will be moved round to *a′ b′ c′*. If rays be now drawn from *a′ b′ c′* to A B C, in nature it will be seen that, instead of meeting at the point O, they form a triangle of error which encloses the observer's position O, the distance of which from each of the rays being proportionate in length to the ray itself, i.e., the longest perpendicular comes from the longest ray, the shortest from the shortest, and so on. (II.) In the second case (Fig. 51) the observer's position is supposed to be outside the triangle formed by the objects A B C, which are represented on the plane-table by *a b c*. Here again, when the plane-table is oriented, as in the position indicated by 1 2 3 4, the rays to the objects will all meet at the observer's position O. But suppose the plane-table to be out of orientation, as 1′ 2′ 3′ 4′, then the points *a b c* will be moved to *a′ b′ c′*, and if rays be then drawn from these to the points in nature A B C it will be seen that they will all pass away (in this case to the left) from the observer's position at O, and will form a triangle of error. Since these rays have all passed away in one direction from the observer's position, it is clear that they must all pass back in one direction to that position. The rule as to the lengths of the perpendiculars from the rays being in proportion to the lengths of the rays themselves holds good as in the first case.

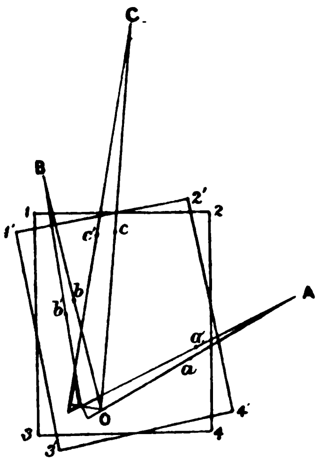

FIG. 51.

three rays will intersect in one point, which is the required position. More frequently, however, the intersections form a small triangle of error, in which case it is necessary to determine the true position.

First, where the observer's position is inside the triangle formed by joining the fixed points. In this case the true position will be within the small triangle of error formed by the intersection of the rays. It will also occupy such a position that its perpendicular distance from each ray will be in proportion to the distance of the observer's position from the respective fixed points.

Thus in Fig. 52, *p* will be the correct position, the perpendicular distances *p a*, *p b*, *p c* being proportional respectively to *p* A, *p* B, *p* C.

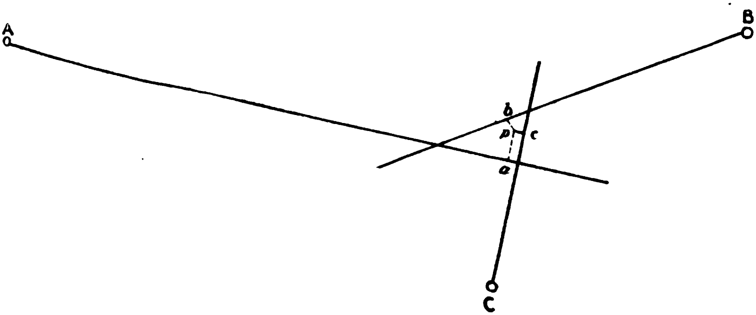

FIG. 52.

Secondly, where the observer has been forced to use three fixed points so placed that his position lies outside the triangle formed by joining them. In this case the point will lie outside the triangle of error.

The same condition holds that the distances of the surveyor's position from the rays will be proportionate to the distances of the respective fixed points; but there is another condition which must be satisfied, that is, that the position must be so situated that all the rays have to move in the same direction round their respective fixed points in order to reach it, when the table is turned in azimuth.

Taking the second condition first, a glance at Fig. 53, p. 130, will show that there are only two possible positions of the fixing which fulfil it, *i.e.*,

in the space C *e g*, where all the rays would have to swing to the right, or in the space A *d f i*, where they would all have to swing to the left.

Now the first condition of the relative distances will decide which position is the correct one. It will be seen that there is no point in C *e g*. which fulfils this condition, but in the space A *d f i* there is one point *p*, the perpendicular distances from which on to the rays A *g* B *h*, and C *i*

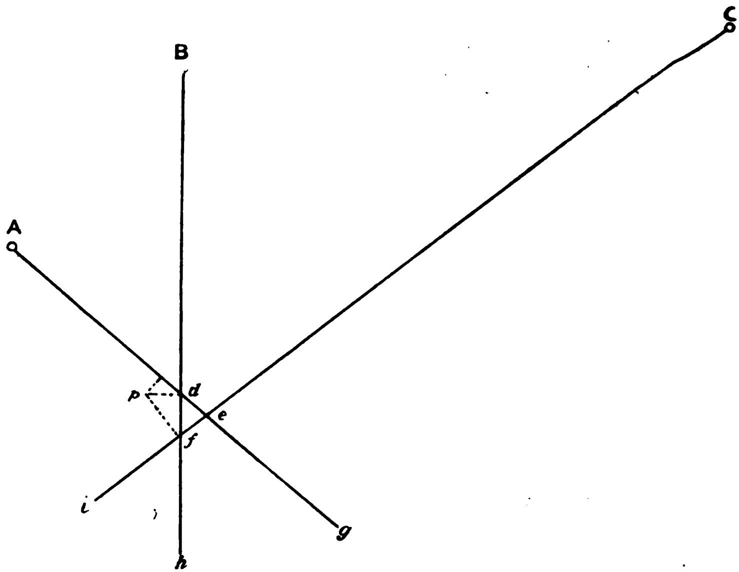

FIG. 53.

are proportional to the distances A *p*, B *p*, and C *p*. With a little practice, the position of this point can be estimated most accurately. In either case, having determined the approximate position of the point, lay the ruler over it and the most distant visible fixed point on the board, and turn the board in azimuth till that point is intersected and clamp it. The interpolation should then be repeated, when, if the point has been

properly chosen, the rays will intersect on it; if any small error still remains, the process should be repeated.

*Second Method.**—In Fig. 55 (p. 132) let A B C be three points in nature and *a b c* the points representing them on the plane table. Fix a pin † in the point *b* on the plane table (*vide* 1), and placing the ruler against it and the point *a*, turn the table round until the point A in nature is intersected; then, clamping the table in this position, turn the ruler and intersect the point C in nature, with the edge of the ruler still against the pin at *b*, and draw the line *b m*. Now remove the pin to the point *a*, and unclamp the table, place the ruler against the pin at *a*, and the point *b*, and turn the table until the point B in nature is intersected (*vide* 2); clamp the table again, and, having intersected the point C as before, draw the line *a n*. Through the intersection *p* of the

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* The following will help to make this second method clear:—Let A B C (Fig. 54) be three points in the district to be surveyed, and A′ B′ C′ their corresponding points on the plane table. The first operation of orienting consists of bringing A′ B′ and B in the same straight line, and then from A′ drawing a line A′ *f* to C. Then this operation is repeated in the opposite direction by bringing B′ A′ and A in line and ruling another line B′ *e* to C. By this means it is clear that the angles *a′ b′* have been made equal to the angles *a* and *b*, or the angles subtended by A B and C at the surveyor's position O. The point of intersection of the rays A′ *f* and B′ *e* and the points C′ and C will then be in the same straight line when the plane table is oriented. This can be shown to be the case by supposing the point of intersection to be at any other point, say at *k*, then the angle at *a′* will no longer be equal to that at *a*, which is impossible, since they have been made equal by construction.

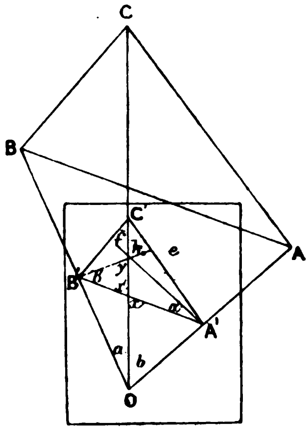


FIG. 54.

† Pins, though found convenient by the beginner, should be dispensed with as soon as possible, owing to the holes they make in the map. An expert soon learns to place the alidade on the points and sight without them.

lines *a n* and *b m*, draw the line *c p q* passing through *c*, the point representing the middle object on the board, and, placing the edge of the ruler against this line *c p q*, unclamp the table once more, and turn it until the point C in nature is intersected (*vide* 3). Now clamp the table, and it will be oriented, and the surveyor's position will be situated somewhere on the line *c p q*; to find this position it is merely necessary to place the pin at *a*, and, intersecting the point A, draw the line A *a x*. The point of intersection, *x*, of this line with the line *c p q* is the position sought. The accuracy of the operation is tested by intersecting the

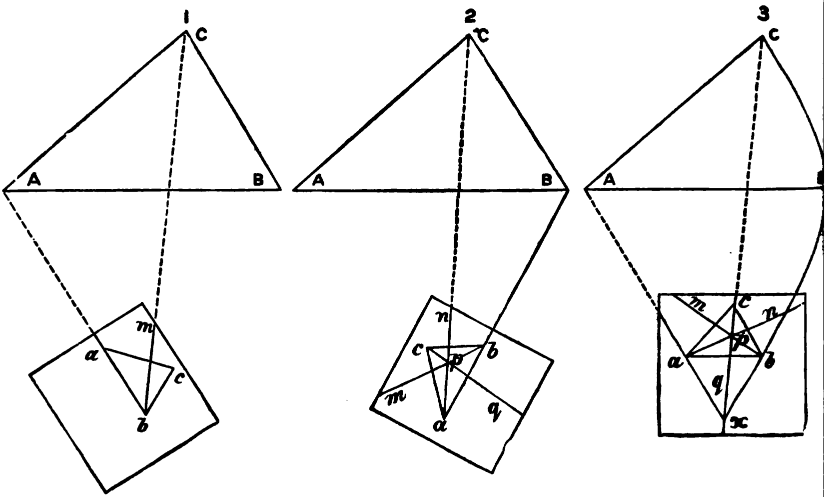


FIG. 55.

other point B in the same manner, and drawing the line B *b x*, which should intersect the line A *a x* at the same point.

When the point *c*, with regard to the point *x*, is situated on the other side of the line A B or below it, the lines *a n* and *b m* will intersect on the opposite side of the line *a b*, to that on which *c* is, and, if the point *x* be situated within the triangle A B C, these lines (*a n* and *b m*) will diverge instead of converge, in which case they must be prolonged in the

opposite direction until they intersect for the point p. The accuracy of this result depends upon the length of the line $c\ p$.

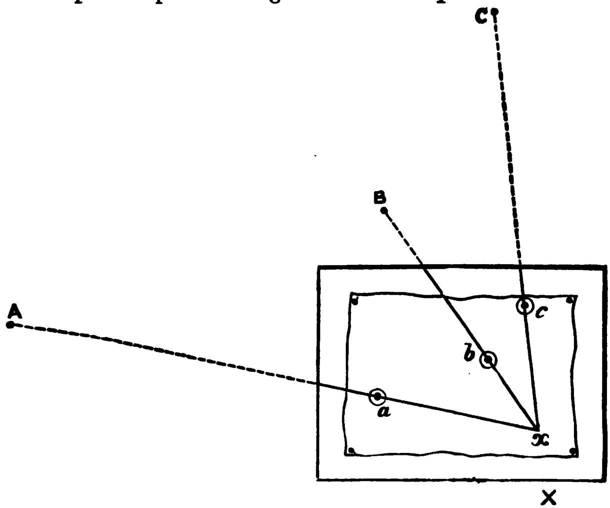


FIG. 56.—(*Good.*)

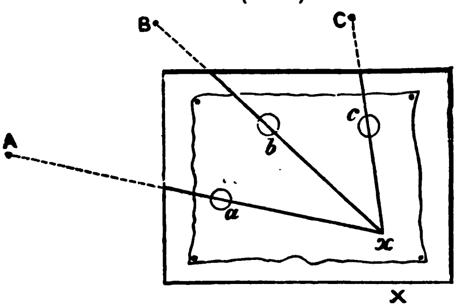


FIG. 57.—(*Bad.*)

Third Method.—Fasten a piece of tracing paper over the survey with drawing-pins, stick a pin in at any point x on the table (Fig. 56),

place the fiducial edge of the ruler against it and point the sights in turn on the stations A B C, on the ground, represented by *a b c* on the plan, drawing lines towards you on each occasion until they meet at *x*. Now take out the pins that fasten the tracing paper to the board, and shift it about until each of the lines passes through its corresponding station, as shown on Fig. 56. Prick through *x*, which will be your position on the plan.

In finding the position and orienting the plane table by either of the last three methods, care must be taken in the selection of the objects:

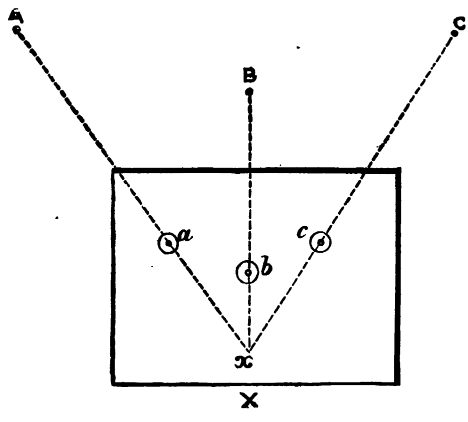


FIG. 58.

they should be as far apart as convenient, and ***in no case should the three points and the surveyor's position be on the same circle***, or even approximately in this position. The best results may be expected when the middle object is nearer than the other two.

For example, a position obtained from objects as in Fig. 57, p. 133, would be of little value, as *x* on the plane table could be moved considerably to the right and left without displacing the several lines off the stations *a b c* on the board, but this could not occur in such a case as is shown by Fig. 56.

For further information on this subject, see a pamphlet, 'On the Station Pointer,' published by the Admiralty, and sold by J. D. Potter, Minories, E.C.

(4.) *Orienting and fixing by the Compass.*—Set up the table over the station X to be fixed, represented by *x* on the board (Fig. 58, p. 134); place the edge of the compass-box against a line drawn on the paper where the needle pointed to north at one of the previous stations, unclamp the table, and turn it about until the needle again points to north. Clamp the table, which will then be oriented. Place the fiducial edge of the ruler against *a*, and turn it until the sights point to A on the ground; draw a line towards you by the ruler, and the desired point will be somewhere on this line.

With the fiducial edge of the ruler against *b*, turn the sights on B on the ground, draw a line towards you by the ruler, and the intersection with the line drawn from *a* will be *x*, the point desired. Using C in the same way will test the accuracy of the work.

Changing the Paper.—When one sheet is full and it becomes necessary to replace it by a new one, to continue the survey, it may be done in the following manner:—Draw a line through the farthest point fixed from the last station. Take the sheet off the table and fix another on, drawing a line upon it in a part most convenient for the work; then cut the sheet just taken off, by the line drawn on it; apply this edge to the line on the new sheet, and as they lie in that position, continue the lines from the other station on the new paper, and prick through the positions of as many stations that have been fixed on the old sheet as you conveniently can. If the positions of three fixed points are thus transferred to the new sheet, the place of a new station can be found in the manner shown on pp. 127–133. On each new sheet place the compass, and revolve the table until the needle points to north, and then draw a dark line which will represent magnetic north, unless the needle is deflected by the influence of local attraction.

To join the sheets together, and thus form one rough map, place the edge of the sheet that has been cut *accurately* against the line drawn on the new sheet, and, with the aid of the ruler, see that the line projected on the new sheet from the last station (on the sheet that has been removed) is an exact continuation of the corresponding line on that sheet.

When a survey has to be made of a considerable tract of country, it will be necessary first to construct the graticules of a map including the area, with Table IX. and in the manner described on p. 89. Place this projection on the plane table and mark on it the positions which have been previously fixed by triangulation or by astronomical observation, either by setting off the latitudes and longitudes, or by rectangular co-ordinates. On one of these positions which promises to give the most extensive view of the country to be surveyed the plane table should be set up and oriented, that is, placed with its meridians true north and south. This can be done as previously described, or if provided with a theodolite or sextant, by determining the true bearing of one of the fixed points by its angular distance from the sun, in the manner shown in Part V., and placing the edge of the alidade on the spots indicating the position of the plane table and the position of the fixed point, the true bearing of which has been determined, turning the table round until the hair in the sights covers the fixed point; then, if the map has been properly projected and the positions of the fixed points accurately laid down, the plane table will be accurately oriented for the true north and south. This should be tested by drawing rays from the other fixed points, and it may still be found that they do not exactly meet at the point indicating the position of the plane table. It will perhaps be possible, by twisting the plane table a little to the right or left, that all the rays may be made to fall on the same point, in which case this point will be the position of the plane table on the map; but should this not be the case, then recourse must be had to the methods shown on pp. 127–132.

Having the plane table thus fixed and oriented in the true meridian, place the compass on the sheet and move it until the needle points to magnetic north while the plane table is in this position; this will enable the surveyor to approximately orient his table in the true meridian should it be set up in a position where he is not able to orient it by points previously fixed. It must, however, be borne in mind that there are countries, such as portions of South Africa, where the local deviation is so variable and so great that this method cannot be depended on.

In many countries which the explorer may visit there are no fixed points, in which case it will be necessary for him to determine by

astronomical observation the latitude and longitude of each end of a base, and from these fix the positions of a certain number of prominent points by triangulation. This being done, he must proceed to fix other points by moving his table to different stations, orienting his table, and drawing rays to them; the intersections of the rays drawn from any two stations to the same point will fix the position of that point, provided the angle of intersection is well chosen, *i.e.*, neither too obtuse nor too acute.

Broken Survey.—The directions given above comprise briefly the fundamental rules of more accurate plane-tabling.

A map, however, may be, and often must be, constructed without the continuous connection of fixed points from sheet to sheet, as is above suggested, and which, in the rough work of an ordinary journey, is frequently impossible.

The traveller may often find that the station from which he wishes to observe rays is beyond the limits of his last sheet, and that none of his fixed points will fall upon it.

In this case he must assume a convenient point on his board as his position, turn the board in a suitable direction with regard to what he wishes to do, and sighting, if possible, one of his old stations, draw a line towards it. Should another former station be visible, another line should be drawn to it. The magnetic meridian must also be drawn by means of the compass. These three lines will enable him to place his new sheet in proper relation to his former one, by arranging them with the meridian lines parallel, and moving one until the continuation of the lines passes through the two former stations. They can then be pasted together in that position, joining them by another strip of paper, if necessary.

Even should there be no fixed stations in view, rays drawn to objects he wishes to fix will be useful, always supposing that he can afterwards fix the position by rays drawn from other stations, never omitting to place the magnetic meridian on the sheet.

New bases must occasionally be measured, and it will be found that one of the chief charms of such surveying lies in surmounting difficulties in the construction of the map. Devices for so doing will suggest themselves in increasing numbers as the traveller gains experience.

Though reliance on the compass should be avoided if possible, from its uncertainty, owing to local attraction, recourse must frequently be had to it, and under favourable circumstance, plane-tabling by its aid gives excellent results.

Concluding Remarks.—On leaving a station, the traveller, when possible, should leave some distinguishing mark behind him, so that he may be able to recognise it again. Where it is possible, as will frequently be the case, he must carefully note the changes which take place in the landscape during his march; he will also do well to write on the plane table sheets the native names of such hills, or conspicuous objects, as he may have fixed on the table, as natives generally know these objects again when viewed from another station, which, from their changed appearance, a stranger would be very unlikely to do. Paper mounted on very thin cloth, and cut to the size of the plane table, will be found serviceable, as it will not easily tear, and can be rolled up and kept in a tin case until wanted. The traveller should also provide himself with a waterproof case into which he can slip the plane table in the event of heavy rain.

From each station draw in the features of the ground around it as far as possible. Rough sketches, made in a sketch-book, will help to complete the drawing, and the work from other stations, when rays have been obtained from them.

A small 3-inch or 4-inch theodolite or a sextant is a valuable adjunct for plane-tabling, as in certain cases the objects may be so crowded in one direction as to confuse the rays if they are all drawn on the board. Angles measured and recorded in a note-book can be plotted hereafter when working up the plan in the tent.

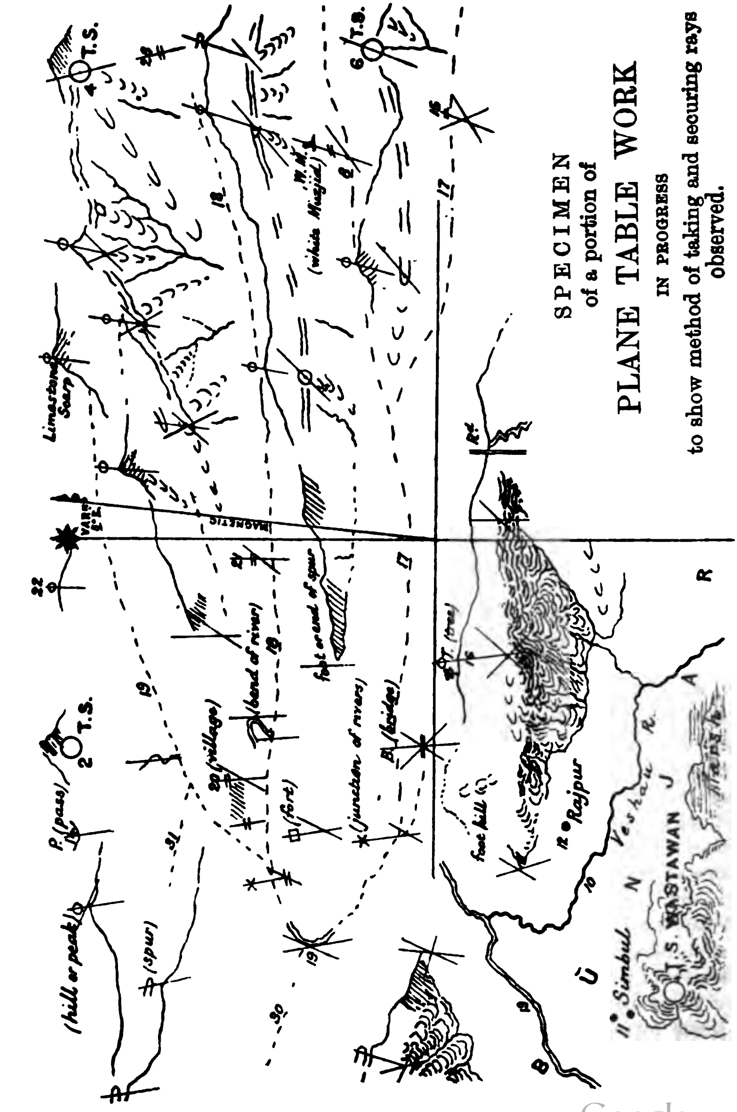
For route surveying or rapid traversing the plane table is a better instrument than the prismatic compass, and whenever possible should be used for this purpose in preference to the latter. The angles are more accurate, as they are plotted at once, without first recording them in a note-book and then afterwards plotting from these recorded angles. In thick bush country, where the track winds continually, the prismatic compass is generally found the most practicable instrument, but there are now several forms of sketching boards on the plane-table principle that could be used with equal facility. Colonel Elliott, R.E., has devised a sort of combination of compass and plane table, or sketching book, which he

found very useful on the Northern Nigerian Boundary survey for filling in detail and rapid route traversing. This consists of a circular compass so arranged that it can be fitted on to the side of an ordinary note-book, which is used as a sketching block. The book is held in the hand and oriented by the compass, then by sighting along a ruler the route can be approximately sketched in. Route surveying with a plane table is conducted on the same principle as by the prismatic compass, except that there is no recording of angles, the map being made as the journey proceeds. Distances are obtained by a subtense instrument, pacing, a time scale, by perambulator, or any other available method, and the route is checked wherever possible by the surveyor finding his position as previously described by fixed points, or by any other means. When the position found by the traversing does not agree with that found by intersection, the latter is accepted as the more correct, and the error in the traverse distributed as described on p. 166.

The plane-tabler should sketch in the *leading* topographical features on the ground, and not leave them till he reaches camp, and then fill them in from notes or memory. The best method of showing hills for this purpose is by means of horizontal form lines, regulating them by fixed heights. For further remarks on this subject, see p. 181 and specimen, p. 200. A note-book is at times useful in connection with plane table work for recording general remarks on the nature of the country and other items of information that may assist in drawing the finished map. A small clinometer, or better still, a small arc attached to the telescopic sight for giving approximate vertical angles, is at times a great assistance, for besides being useful for contouring, the vertical angles will often assist in the identification of the peaks later on.

It will not, as a rule, be necessary to draw the whole length of the rays, and, to save crowding the map, instead of writing upon them the names of the objects to which they run, it is preferable to use reference numbers.

A few ordinary precautions must be taken to ensure good results in plane tabling. The table must be levelled, the edges of the alidade must be true and parallel to each other, and when the ordinary sights are used they must be perpendicular to the ruler itself, and it is often a convenience for sighting objects of considerable altitude, to stretch a thread



SPECIMEN
of a portion of
PLANE TABLE WORK
IN PROGRESS
to show method of taking and securing rays observed.

of silk from one sight to the other, so that they can be intersected. The pencil must be sharp and held perpendicular, so that the ray drawn is the same distance from the edge of the alidade as the station dot. The triangles should be neither too acute nor too obtuse, somewhere between 30° and 90°, if possible.

On p. 140 is a specimen of an unfinished plane table sheet given here to show the method of operation. It is from a plane table survey by Lieutenant-Colonel H. H. Godwin-Austen, F.R.S., who was for many years an officer of the Survey of India.

Theodolite Traversing.

The method of carrying on a Latitude and Azimuth Traverse has already been described, p. 117.

In the case of long traverses on which the distances between the stations have been as accurately measured as circumstances permit, and the angles between them carefully taken as shown, p. 42, the Latitudes, Longitudes, and Azimuths of the stations of the traverse should be computed as shown, pp. 108–110. For shorter theodolite traverses the stations are usually laid down by rectangular co-ordinates.

There are several methods of theodolite traversing, but those in general use are (1) by making any convenient point zero and measuring all angles from a line through every station parallel to the line joining the first station with the zero point; (2) by making the station last left zero, and measuring all angles from that. The principle involved in each of these is the same, viz., making zero with the lower set of screws and measuring all angles with the upper set of screws. The distances between the stations along the route traversed must be accurately measured by the best available means.

The following is an example of the *first method*, traversing from A to D.

Set the theodolite up at A (Fig. 59), level it, adjust for parallax in the manner described (p. 33), and note the magnetic bearing of the zero line. With the instrument F R, set the A vernier of the horizontal circle at 180°, and clamp it. Loosen the clamp of the lower plate, direct the telescope on the point Y, chosen for zero, and, using the *lower* set of

screws, bisect it with the cross wires in the diaphragm of the telescope and clamp it firmly. Now, keeping the lower clamp fast, release the clamp of the vernier plate and take a round of angles to all objects the positions of which it is desired to fix, reading F R and F L and both A and B verniers, using only the upper set of screws; then in the same manner take the angle to the next forward station, B. Underline in the field-book the reading of the *same* vernier which was set to zero of the angle to the forward station, and keeping the plates clamped,*

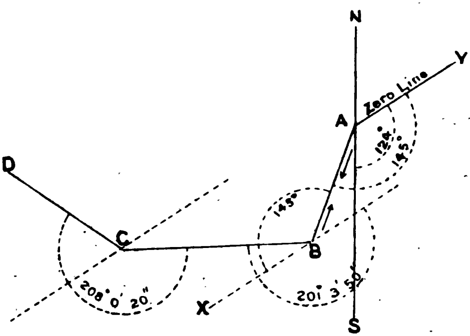


FIG. 59.

carry the theodolite to B, where it must be set up, the *lower* clamp being loosened for levelling. With the two plates still clamped together, turn the telescope back on A, using only the *lower* set of screws. When this is done, release the clamp of the vernier plate, and take a round of angles as before, finishing with the angle to the next forward station, C. The traverse is carried out in this manner to all the forward stations. The work may be tested at each forward station, to see that no serious error has occurred, by setting the vernier to 360°, and noting if the compass bearing is the same as at the first station. In plotting the

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* If the angle should be changed, accidentally or otherwise, it must be carefully set on again immediately the forward station is reached.

work it must be borne in mind that all angles are measured with reference to the zero line.*

The *second method* differs from that previously described, in which all angles are referred to a common zero line, as it consists of making the station last left zero, and taking rounds of angles at each station to the points it is desired to fix.

The *first* of these methods is better adapted to the computation of the points by rectangular co-ordinates in the manner described on p. 149, especially when the final station is not visible from the first, which is often the case. To take full advantage of this method the position of A must be known and the azimuth of the zero line determined by astronomical observations. (The manner of doing this latter is shown on p. 258.) When the azimuth of the zero line is known, it may be applied as a constant to the forward angles at each station, but it should be remembered that owing to convergency of the meridians after leaving the first station, it is no longer the true azimuth.

This method furnishes a ready means of checking the work, for if at the last, or any other station, the vernier is again set to zero before the instrument is moved, then the azimuth of the zero line, again ascertained

* The principle underlying this method, by which the round of angles taken at any station and the angle from any station to the forward station are all measured from the line passing through each station parallel with the zero line, will be clear upon a little consideration. When the theodolite is set up at A with Y as zero, after taking a round of angles, the angle to the forward station B is measured, and it is clear that the telescope is pointing towards B, the angle reading 145°. The vernier plate is clamped at this angle, and the theodolite carried to station B, where, without disturbing the vernier plate reading, by means of the lower plate clamp and tangent-screws the telescope is sighted back on to A. By inspection of Fig. 59, it will now be seen that the angle 145° has been reversed, and the 360° on the vernier plate brought round to the opposite direction to that occupied by it when at A. Now since the angles Y A B and X B A are equal (both 145°) the line X B, from which the angles at B are measured, must be parallel to the zero line A Y, from which the angles at A were measured; the only difference in the two positions being that the vernier plate has been reversed, the 180° taking the place of the 360°; hence, whilst at A the direct angles are read with the A vernier, at B they are read with the B vernier.

from astronomical observations, should be the same as that resulting from the observations at the first station, *plus, or minus, the difference of azimuth*, which can be computed, or taken from a table giving the convergence of meridians, such as that in the Survey of India 'Auxiliary Tables.' When any error exists it must be distributed proportionately throughout the traverse.

The following is an example of this work, including the manner of recording the angles in the field book and the form for computing the co-ordinates. The measured distances must be reduced by multiplying them by the cosine of the angle of elevation or depression to the forward station. When great accuracy is not required, traverse tables may be used in working out the distances, but these do not usually read near enough to give exact results, and when much interpolation has to be done, it takes very little longer to compute by logarithms, which is accurate.

The error on the closing point of a theodolite traverse can be distributed graphically, as shown on p. 166, or computed and distributed proportionately by the following rule:—

Rule for Distributing the Closing Error of a Theodolite Traverse.—Correction for the error on the closing point in a traverse when the first and last stations are mutually visible from each other, can be made as described in 'The Text-Book of Topographical and Geographical Surveying,' as follows:—

Suppose the legs of the traverse together with the line A B form an enclosed figure, then the sum of all the interior angles should be equal to twice as many right angles as the figure has sides, less four right angles. We thus have a check on the observed horizontal angles.

It should be carefully noted that the included angles at the stations are always measured, either all to the right or all to the left of the back station. If necessary they must be reduced to these, which can easily be done by taking the differences between the angles to the forward stations if they are not directly measured. For instance, in the traverse shown on p. 148, the interior angle A B C is clearly equal to $180° - (Z_1 B C - Z A B)$, reckoning these two latter angles as measured round to the right, and so with the others.

In the case of Fig. 60 the angles are all measured to the left of the back station.

The sum of all the interior angles then should be equal to $(2n \times 90 - 360)$ degrees, where n is the number of sides to the figure. Any discrepancy between these two is called the "total angular error." This error must

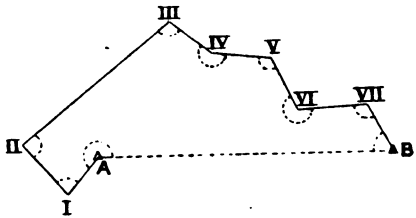


FIG. 60.

be distributed equally among the observed angles. For example, if there are six sides to the figure, and the sum of the observed angles comes out to 719° 59′ 0″, then the error to be distributed is 1′. Hence 10″ must be added to each angle.

The manner of computing the rectangular co-ordinates is shown on pp. 113, 149, and in this class of traverse a rigorous adjustment of the errors is unnecessary. A simple rough and ready way to distribute the errors of the co-ordinates is as follows:—

n = number of legs of traverse,
y = error to be adjusted N. and S.,
x = error to be adjusted E. and W.

then the several corrections to be applied to the points of the traverse in order will be

$$\frac{y}{n}, \frac{2y}{n}, \frac{3y}{n} \quad . \quad . \quad \frac{ny}{n},$$

$$\frac{x}{n}, \frac{2x}{n}, \frac{3x}{n} \quad . \quad . \quad \frac{nx}{n}.$$

From an inspection of the diagram showing the traverse it will be seen whether the corrections are + or −.

It often happens that the traverse crosses and recrosses the line joining the two terminal points, as in Fig. 61.

In such a case, where the traverse is started at C, the angle required at C must be under 180°. In Fig. 61 this angle is measured to the left

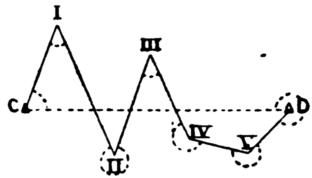


FIG. 61.

of the back station D. As stated before, all the other angles must be so measured.

Then, as before,

$$\Sigma\,\theta = 2\,n \times 90^\circ - 360^\circ$$

if the traverse crosses C D an *even* number of times.

Where, however, the traverse crosses C D an *uneven* number of times:

$$\Sigma\,\theta = 2\,n \times 90^\circ$$

In each of these examples it is assumed that the last station of the traverse is visible from the first, but where this is not the case the angular error can be ascertained and corrected for, as described on p. 143.

Specimen of Field Book for Traverse.

Record of round of angles taken at B to points over 180°	C	Record of round of angles taken at B to points under 180°

C

HORIZONTAL.

		°	′	″
F. L.	A	21	3	40
	B	201	4	10 *
F. R.	A	201	4	10
	B	21	3	20

VERTICAL.

		°	′	″	E.	O.
F. L.	C	88	52	30	8	10
	D	88	52	40		
F. R.	C	1	7	20	10	8
	D	1	7	30		

521·96 feet.

Record of round of angles taken at A to points over 180°	B	Record of round of angles taken at A to points under 180°

B

HORIZONTAL.

		°	′	″
F. L.	A	160	43	10
	B	340	43	40
F. R.	A	340	43	40
	B	160	43	30

VERTICAL.

		°	′	″	E.	O.
F. L.	C	88	8	40	10	9
	D	88	8	20		
F. R.	C	1	51	20	9	10
	D	1	51	40		

740·54 feet.

A

Tower on hill made zero. Magnetic bearing of zero line—79° 58′ 30″

* In this method of traversing the direct forward angle would be always read F L at the first station with A vernier or micrometer, and then at the next station with B vernier or micrometer. This angle is usually underlined, the others being used to furnish a mean.

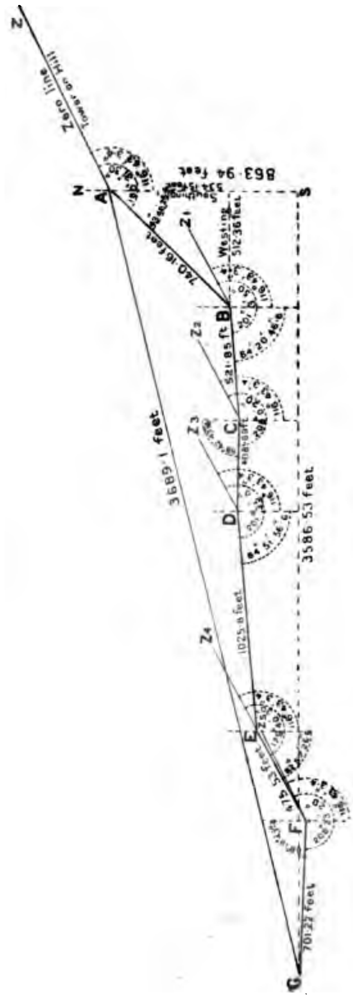

Z
Zero line
Tower on Hill
N
A
S
863·94 feet
Westing
512·36 feet
740·16 feet
Z1
B
Z2
521·85 ft
C
Z3
D
3689·1 feet
3586·53 feet
Z4
1025·6 feet
E
F
701·22 feet
G

FIG. 62.

Station.	Mean of Angles to Forward Station. Corrected.	True Bearing of Zero Line (from Astronomical Obs.).	* Bearing of Forward Station.	Measured Distance.	Vertical Angle. (+elevation −depression)	† Corrected Distance.	Co-ordinates. (Corrected for Closing Error.) N	S	E	W	Reduced Co-ordinates. (Corr. for Closing Err.) S	W
	° ′ ″	° ′ ″	° ′ ″	feet.	° ′ ″	feet.	feet.	feet.	feet.	feet.	feet.	feet.
A to B	180 31 30	S 116 43 3·4 E	S 43 48 26·6 W	740·55	− 1 51 30	740·16	...	534·15	...	512·36	534·15	512·36
B to C	201 3 50	„ „ „	S 84 20 46·6 W	521·96	− 1 7 25	521·85	...	51·41	...	519·31	585·56	1031·67
C to D	208 0 20	„ „ „	N 88 42 43·4 W	409·37	− 2 45 45	408·89	9·19	...	...	408·7	576·37	1440·37
D to E	201 35 0	„ „ „	S 84 51 56·6 W	1026·50	− 2 7 55	1025·8	...	91·81	...	1021·7	668·18	2462·07
E to F	179 40 30	„ „ „	S 62 57 26·6 W	475·59	− 0 44 8	475·53	...	216·20	...	423·54	884·38	2885·61
F to G	208 23 20	„ „ „	N 88 19 43·4 W	701·45	+ 1 28 15	701·22	20·44	...	...	700·92	863·94	3586·53 ‡

* This is sometimes called the False Bearing, as no allowance has been made for the convergence of the Meridian.

† The corrected distance = the measured distance × cos angle of elevation or depression to the next station.

‡ As a check on the computation it is evident that, after correcting for closing error, the sum of the southings in the Reduced Co-ordinates should equal the sum of the southings minus the sum of the northings of the Co-ordinates, and the same with the eastings and westings.

Example of Computation.

A to B (Fig. 62).

Measured distance . 740·55 feet log 2·869553

Vertical angle . 1° 51′ 30″ log cos 9·999772

Corrected distance . 740·16 feet log 2·869325

740·16 feet . log 2·869325 | log 2·869325

Bearing of forward station— (B from A) 43° 48′ 26″·6 {log sin} 9·840254 | log cos 9·858339

feet

Westing 512·36 = log 2·709579 | log 2·727664 = 534·15 southing.

And so with all the other triangles in the traverse.

To compute distance AG *in triangle* ASG. (Fig. 62).

$$\text{Tan AGS} = \frac{\text{AS}}{\text{GS}}$$

AS = 863·94 feet log 2·936483

GS = 3586·53 „ log 3·554675

∴ ∠AGS = 13° 32′ 37″·3 = log tan 9·381808

and ∠GAS = 90° − 13° 32′ 37″·3 = 76° 27′ 22″·7

Distance AG = GS × sec AGS

GS = 3586·53 log 3·554675

∠AGS = 13° 32′ 37″·3 log sec 10·012248

∴ AG = 3689·1 feet log 3·566923

Surveying with the Subtense Instrument and Tacheometer.

(*For description of the Subtense Instrument, see* p. 58).

The method of surveying with a subtense instrument, such as shown (p. 59) is, as regards fixing positions of distant objects, the same as with the prismatic compass. This instrument has however the advantage over the prismatic compass, that distant objects are seen much more distinctly through the telescope, and the bearings can therefore be more accurately taken than when the ordinary sight vanes of the prismatic compass are used. In addition to which, the compass is larger than the prismatic compass usually carried by the traveller. The principal advantage of the subtense instrument or tacheometer, however, will be found when it is employed for fixing positions within comparatively short distances. This is done by sending an assistant to the spot it is desired to fix, with a staff such as is shown on pp. 61, 62, and with the micrometers, measuring the angle it subtends when held (either horizontally or perpendicularly) at right angles to the line of sight, at the same time taking the compass reading through the prism. With the angle measured by the micrometers, if a ten-foot staff has been used, knowing the value of the micrometer divisions, the distance of the object can be at once obtained from Table XXXII. With the distance so found, and the bearing which has been taken, the position of the object can be at once laid down on the survey by setting out the bearing from the point of observation, and then measuring the distance, taken from the scale of the map.

With any other length of staff than ten feet, Table XXXII. cannot be used without calculation, and the distance of the object will have to be computed. It is usual, when observing the angle subtended by the staff, to measure half of it with each micrometer, the sum of which measures will, of course, be the whole angle subtended. The distance from the staff is computed in the following manner:—Multiply the total number of divisions used in *each* micrometer by the value of a single division of that micrometer, add the results together, and this will be the value of angle in *seconds*. Divide the length of the staff, in feet, by the angle in seconds and multiply the result by the cosecant of $1'' = 206265$. This will give the distance between the instrument and the staff, in feet.

Example:—Length of staff, 12 feet; divisions used, Left Micrometer,

581·9; value of each division, 2″·31; Right Micrometer, 575·2, value of each division, 2″·04.

Left Micrometer.	Right Micrometer.
581 9	575·2
2·31	2·04
5819	23008
17457	11504
11638	1173408
1344·189	1344189
	The angle in seconds = 2517·597

	ft.
Log 12 =	1·079181
Log 2517·6 =	3·400986
	3·678195
Cosec 1″= 206265 Log =	5·314425
Log distance in feet, 983·2 =	2·992620

The rod, though convenient, is not absolutely necessary, as distances can be measured by this class of subtense instrument without it, by making an assistant set up two staves at a carefully-measured distance from one another, and at right angles to the line of sight. The angle subtended by these staves is measured with the micrometers, and the distance computed in the manner already shown.

The subtense instrument with the movable wires is preferable for long distances, as it is often impossible to read the figures on a staff such as that employed in the fixed wire system, but for shorter distances the latter is very convenient. The following is a description of the fixed wire system:

An ordinary theodolite has a bi-convex object-glass and an eye-piece, and it is easy to show that the point at which the angle subtended by the fixed wires is constant is not on the vertical axis of the instrument, but at a distance $f + c$ in front of the vertical axis measured towards the bar, where

f is the focal length of the telescope (at solar focus),

c is the distance of the centre of the object-glass from the vertical axis.

f can be measured by focussing the telescope on a distant object and measuring the distance from the centre of the object-glass to the diaphragm.

Hence, if d is the required distance from vertical axis of theodolite to centre of bar, the bar being held vertically, the telescope being horizontal, if

a is the distance intercepted on the bar by the wires,

k a constant,

$$d = k, a + (f + c)$$

k should be determined by experiment by taking several readings of the staff at 100, 200, and 300 feet distant, measuring from a point $f + c$ in front of the vertical axis.

If the rod is held vertically, but on a different level from the telescope, so that the latter is inclined at an angle a to the horizon when pointing at the centre of the rod, using the same notation as before,

$$d = k\, a \cos^2 a + (f + c) \cos a,$$

and the difference of height (h) between the axis of the theodolite and the mean reading of the staff is given by the expression

$$h = (f + c) \sin a + a\, k \frac{\sin 2a}{2}$$

The rapid and effective use of tacheometer methods thus clearly involves the employment of tables. There are several such tables in existence, such as those in 'Theory and Practice of Surveying,' S. B. Johnson. (Wiley and Sons, New York.)

A theodolite with fixed hairs, such as described (p. 28) may often be used for measuring distances approximately when it is impossible to read the markings on a graduated staff. This is done in the following manner:—An assistant should be sent to the object, the distance of which is required, and directed to place a staff in the ground. The surveyor must then cover the staff with one of the fixed hairs in the instrument, after which the assistant must move, very slowly, in a line at right angles to the line of sight until he is covered by the second fixed hair, when he might be stopped by some pre-arranged signal, and place another staff there. He must then carefully measure the distance between these two staves, which distance multiplied by the ratio between the value of the hairs, which is generally 1 in 100, will be the distance of a point, midway between the two staves, set up by the assistant, and the observer. Thus, if the measured distance between the staves was 10 yards, the distance from the instrument would be $10 \times 100 = 1000$ yards.

Surveying on the tacheometer principle, but without a tacheometer, may be carried to greater distances in the following manner.

Suppose a densely wooded plain over which it has been impossible to preserve any record of the distance travelled, but with elevated country at its extremities, the distance between points on the elevated lands may be very accurately found by measuring a base on one at right angles to the position on the second, of such a length that it will

subtend an angle of two or three degrees to an observer at the second point; and marking these ends either by choosing conspicuous trees or other marks, or by flashing from them with a mirror, or by making fires. The observer obtains the angle by a theodolite or sextant between the ends of the base, and by simple right-angled trigonometry calculates the distance.

A method similar in principle to that of obtaining distances with the subtense instrument with movable wires by means of micrometers is that described by the late Colonel H. C. B. Tanner, I.S.C., in his paper read before the British Association at Cardiff in 1891, from which the following is taken. It consists of measuring the angle subtended by a rod of known length on the horizontal plate of the theodolite repeatedly in different parts of the circle and taking a mean result, and when only an ordinary theodolite without a micrometer eyepiece is available this might be often practised with advantage. Colonel Tanner found the system he describes to give very satisfactory results.

The system is readily acquired by native surveyors after a week's instruction, and in their hands, over the roughest possible mountain tracts, is capable of furnishing horizontal measurements up to a maximum of some two miles with an error of about three feet per mile, and up to a distance of three miles with a somewhat greater error; and an adaptation of the process is capable of yielding reconnaissance traverses and approximate trigonometrical work far more accurately and expeditiously than can be looked for by any other means, unless a regular trigonometrical survey be resorted to.

The theodolite used should be six-inch, or larger; it should be simple in construction, and furnished with one vertical and one horizontal wire. The bars may be of varying lengths. In the Himalayas the twenty-foot bar was in general use, but ten and two-foot bars were found convenient for some purposes. A twenty-foot bar with twelve-inch circular discs (as shown on p. 61) is capable of furnishing, under favourable conditions of light and atmosphere and by a skilled observer, a three-mile distance with an error of six feet. A ten-foot bar with eight-inch discs will give good results up to a mile-and-a-half, and a two-foot Gunter's scale blackened at the ends with two-inch paper discs pasted on two feet apart, and properly mounted, will give distances up to twenty chains.

The *modus operandi* of a traverse surveyor must now be explained in detail.

The forward signalman sets up the horizontal bar over the station mark, and then, by means of the folding sight-vane, directs the bar at right angles to the observer, who then intersects and records the reading of the back signal. Then, leaving the lower clamp fast, he releases the upper plate and intersects the right-hand disc of bar, the reading of which he records.

Now release lower clamp (leaving upper clamp fast) and intersect left-hand disc. Again release upper plate and intersect right-hand disc, and for a second time the left-hand disc with lower plate, and so on, continuing the repetition until, say, ten times, and then read and record the right-hand disc. In this operation the graduated limb of the theodolite will have moved over an arc ten times greater than that subtended by the bar. Now repeat again, ten or twenty times, and record readings of right-hand disc, and then, having taken a vertical angle to bar, and leaving lower plate fast, intersect, and record the reading of back signal with upper tangent screw, and such a record as shown below will have been obtained :—

Signals observed.		Reading of A vernier.	Differ-ences.	Subtended angles.		Error of 20 ft. bar −0·2 of an inch.
		° ′ ″	° ′ ″		′ ″	
Back station .	A	126 14 20				
Right-hand disc	B	206 26 30				
„ „ .	B_2	209 48 30	3 22 0	d	20 12	
„ „ .	B_3	213 10 15	3 21 45	d_2	20 10·5	
„ „ .	B_4	216 32 5	3 21 50	d_3	20 11	
Back station .	A_2	136 19 55	M 20 11·2 = x.			
(30 repetitions) .		10 5 35	From Table, Chains . .			51 60*
		10 5 35	Correction † . . . −			4
Subtended angle	x	20 11·2	Corrected distance . .			51 56

* For actual use the distances have been tabulated between 2 and 180 chains.

† Bar = 20 ft. = 30·3 lks. log 1·48144
20′ 11·9″ cosec 2·23122
51·60 log 3·71266

	°	′	″
Traverse angle :—B – A (= B_4 – A_2)	80	12	10
$\frac{x}{2}$ –		10	5
Angle at station 1, between back station and centre of bar at No. 2.	80	2	5

A 10-foot bar with an error of 0·2 of an inch would give—

Chains	25·80
Correction .. –	·08
Corrected distance, ch.	25·72

A 2-foot bar with an error of 0·02 of an inch would give—

Chains	5·16
Correction .. –	·1
Corrected distance, ch.	5·15

Attention is drawn to the complete system of checks on the observations furnished by the above record. In the first place, there are two values of the azimuthal or traverse angle B – A and $B_4 - A_2$, both of which should nearly correspond, and show only trifling differences.

The subtended angle, or x, which is D divided by the number of repetitions, should correspond very closely with d_1, d_2, d_3, and as a check of the arithmetic, it should agree exactly with the mean of d_1, d_2, d_3. These values are taken out during the progress of the observations, and should one of them show even a small discrepancy, the work must be condemned and done *de novo*. Again, $A_2 - A_1$ and $B_4 - B$ must agree very closely. The checks are such that, by examining his record, the observer can make certain before proceeding to his next station that he has obtained the correct distance. Up to a mile he can detect any error made by the signalman in placing the bar at right angles, for it is only when exactly set that the black lozenge at the end of the sight-vane of the bar appears to him in the middle of the white patch on the bar itself.

The signalman soon learns to place the bar sufficiently near the horizontal for practical purposes. An error of 2° of dislevelment, which

would seldom occur in practice, would only produce an error of about three inches in a mile.

The manner in which this method may be made applicable to other classes of survey is shown in Col. Tanner's paper, published in "Proceedings of the Royal Geographical Society," November, 1891.

Route Surveying.

As previously stated, the plane-table is a better instrument for rough route surveying than the prismatic compass, and even a small plane-table or sketching board will, as a rule, give better results than the latter. Still, there are occasions, as in traversing a winding path through a thickly-wooded country, when a prismatic compass has to be used, and in the hands of an experienced explorer, who takes precautions against the effect of local attraction, and otherwise knows how to make the best use of the instrument, good route-traversing and filling in work can be done with it.

Route Survey with Prismatic Compass, Boiling-point Thermometer, and Aneroid—For the purpose of illustration, suppose the following to be an extract from a traveller's journal:—

June 1st.—Camp at the foot of hill A, and two miles distant from its summit, the magnetic bearing of which was 146°.

To measure the height of the hill A, above the camp, I read the aneroid and thermometer, first at camp and then on its summit, with the following results:—At camp, aneroid, 25·67 inches; temperature in the shade, 70° Fahr.; at the summit of the hill, aneroid, 24·25 inches; temperature in the shade, 65° Fahr.; at the summit of hill A, I took the following bearings, and made a rough sketch of the country to the north, marking all prominent objects with a letter corresponding to the letter given to the bearing.

Bearings taken at A: G 351° 30′; F 340°; E 326°; D 308°; C 300°; B 283°. All bearings magnetic.

June 2nd, 8 A.M.—Aneroid, 25·7 inches; temperature in shade 78° Fahr. Struck camp, and travelled in a direct line towards hill marked E in the sketch, and at a distance, which I estimated to be twelve miles, we arrived at the right bank of a river, where we camped for the

night. The country over which we have passed this day is destitute of trees, sandy, with patches of grass here and there, and gradually slopes downwards from our last camp to our present position. 6 p.m.: aneroid, 25·98 inches; temperature in the shade, 68° Fahr.; took the following bearings:—

Bearings taken at camp, 2, by river: D 270°; B 204°; A 146°; G 100°; F 8°. All bearings magnetic.

June 3rd, 8 A.M.—Aneroid, 26·05 inches; temperature in shade, 78° Fahr. Struck camp, and forded the river, which, after winding in an easterly direction from the hill, marked D in the sketch, to a point one-and-a-quarter miles N.E. by E. of the ford, takes a bend to the S.E., passing to the west of the hill marked G on the sketch. At a distance of half a mile below the ford, a large stream from the north flows into the river. Continued to travel in the direction of E, and at noon found that we had arrived at a point where C and F and our position were in one line of bearing—81° and 261° magnetic. During our halt, boiled a thermometer and read the aneroid, with the following results: water boiled at 204·3°; aneroid, 25·62 inches; temperature in the shade, 71° Fahr. 3 p.m.—Resumed our journey, and at 6.30 p.m. reached the summit of the hill E, where we camped; estimated distance travelled, sixteen miles. Aneroid, 24·60 inches; water boiled at 202·3°; temperature in the shade, 64° Fahr. Since leaving camp this morning, the country through which we passed was covered with vegetation, and we had the large stream to the right of us throughout the day. From this hill, E, we can see that the river we forded this morning takes its rise in the range of hills to the west of our present position, and flows with a winding course through the valley at the foot of the hill D, and so past our last camping-ground.

Bearings taken at E: C 236° 30′, and southern end of summit of same range, H 215°; D 174°; B 168°; A 146°; G 133°; F 118° 30′. All bearings magnetic.

June 4th, 8 A.M.—Aneroid, 24 65 inches; temperature in shade, 66° Fahr. Set out in a N.W. direction, and having no prominent object in view on the line of march, I noticed the direction in which my shadow was cast, and by this means, allowing for the sun's apparent motion, I avoided making any general deviation from the direction in which I wished to travel. Arriving at a small lake, we camped, having come an

estimated distance of ten miles. Fixed the position of the lake by bearings of C and E*. Aneroid, 25·50 inches; temperature in shade, 70° Fahr.

Bearings taken at camp, near lake: C 195° 30′; H 185° 30′; E 118° 30′. All bearings magnetic.

To Plot the Bearings.—This can be done either on the true or magnetic meridian. The bearings being magnetic, it saves much trouble, and also chances of errors, to plot them from the magnetic meridian.

Through the station A draw with a pencil a line to represent the magnetic meridian in a direction convenient for the route. Place the protractor with its centre mark on A, and the 360° on the magnetic line, and set off the bearings observed.

The second camp being in the direction of hill E, measure eighteen miles, on the scale adopted, on the line drawn toward E, which will give the position of Camp 2.

From this position lay off the bearings obtained, in a similar manner, having first drawn a magnetic meridian through it parallel to the first. The intersection of two lines of bearings of any one point, as taken from two different stations, will fix the position of that point with reference to the stations. If the true meridian is used, the procedure is the same, but the bearings must be corrected for the variation of compass, which can be approximately ascertained from the variation map facing p. 162. The line drawn through A will then represent the true meridian. In both cases it should be stated on the map whether the meridian is true or magnetic.

Each station where bearings are taken must be plotted in a similar manner to Camp 2, that is, by bearing from the last station, and by estimated distance. Having by means of the first two stations fixed hills off the line of march, bearings of these will assist to obtain the position of the third, and so on. When no object can be seen to march for, the direction must be obtained by compass bearing of the line of march obtained from time to time.

The aneroid readings, and the boiling-point, furnish the means

* Take 180° from C for its opposite bearing. Add 180° to E for its opposite bearing.

of ascertaining approximately the difference in height of two stations, which may be computed as shown, pp. 190–193, or, where the height is not considerable, by a simple arithmetical process as follows:—

Take the sum and difference of the aneroid readings, at the upper and lower station, get the mean of the temperature in the shade at the two stations. Then, sum of readings : difference of readings : : 55,000 : the difference in height. Increase the result thus found by $\frac{1}{435}$ of itself for every degree that the mean temperature in the shade at the two stations exceeds 55°; subtract the like amount if it is below 55°. The aneroid readings in the example, computed by the tables and this formula, will show a fairly close agreement.

	Approximate Method. Feet.	By Tables. Feet.
A, above Camp 1	1608·5	1603·8
1st Camp above 2nd Camp	310	308·8
Foot of Range above 2nd Camp	477·2	475·9
Height of Range E	1148·2	1145·0
,, by Boiling point		1155·3
E above Lake	959·2	956·5

For plotting the work in the field, the $\frac{1}{125000}$ scale, or about two miles to an inch, will exhibit all the main features of a country traversed in a day's journey. Special plans must be drawn on a scale suited to the area they are intended to represent; but whatever scale is chosen for the field work, it should be large enough to admit of considerable reduction in the fair plan, as by this process all errors are diminished. The projection of maps is purposely omitted here, as it is dealt with separately (*see* p. 88 *et seq.*); it will, however, be of great assistance to the traveller if he provides himself with a blank map of sufficient range in latitude and longitude to include the country he intends to explore. He should also procure some paper ruled with dark lines into inch squares, and then again subdivided into five smaller squares; this will be useful to him for plotting his work in the field, and should be made up in the form of an ordinary sketching-block. Should the latitude and longitude of the point of departure be known, the latitude and

longitude of any place on his route can be approximately determined by working the traverse.

It must not, however, be supposed that an accurate survey of a large tract of country can be made with the aneroid, prismatic compass, and boiling-point thermometer; the most that a traveller could expect to do with the aid of these instruments would be to make a rough sketch of the country through which he passed. But instances are not wanting where travellers, by a judicious use of these simple instruments, have added very considerably to our geographical knowledge.

The weak points in this method of surveying are, the errors caused by false estimates of the distance travelled, and those arising from the effects of local attraction on the compass. Knowing these sources of error, every care should be taken to guard against them. With regard to distance, the only safe way of estimating it is, by carefully noting the time occupied in passing from one place to another. In almost all countries bodies of men have a nearly uniform rate of progression, and by taking an early opportunity of noting this rate, the distance traversed in a known period of time can be fairly estimated. The only precautions that can be taken against the effects of local attraction on the compass are to be careful when taking a bearing to put all arms, such as rifles, at some distance from the compass; as a general rule, where possible, to avoid all rocks; and to take bearings both forward and backward on the route travelled. These should, of course, differ by 180°; when this is not the case the error must be equally distributed between the two. In a country thickly covered with forest it is most difficult to distinguish landmarks. The traveller may, however, sometimes leave a mark recognisable at some miles distance by giving a little consideration to it, and knowing the direction in which he is proceeding.

Enter every observation and change made in the general direction travelled, with the date and time, in the journal; as without attention to this much valuable information may be lost. When preparing MS. to be sent home for publication, write each of the native names, *at least once*, in printing character. Numerous errors and great loss of time frequently result from the attempt to decipher proper names written by travellers in their ordinary handwriting only.

As previously stated, the weak points in route surveying with prismatic compass are the errors caused by false estimates of the distance travelled, and those arising from the effects of local attraction on the compass. It is by no means easy to guard against these errors creeping in, and false estimates of distance are frequently brought about by the different nature of the surface of the country travelled over, as, for instance, when there is a change from firm open country to jungle or heavy sand, as the times occupied to traverse the same distance under these changed circumstances will differ considerably, and a time scale prepared for one will be useless for the other.

It is here that astronomical observations become so valuable for correcting errors arising from the above sources, and even if a traveller has only a sufficient knowledge of these to take the latitude, this will go far to increase the accuracy of his map, as the following diagram will show.

Suppose a person to travel from A to B (Fig. 63) in the direction A B,

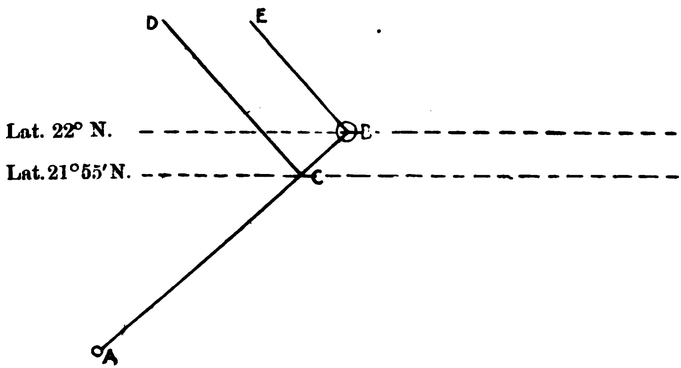
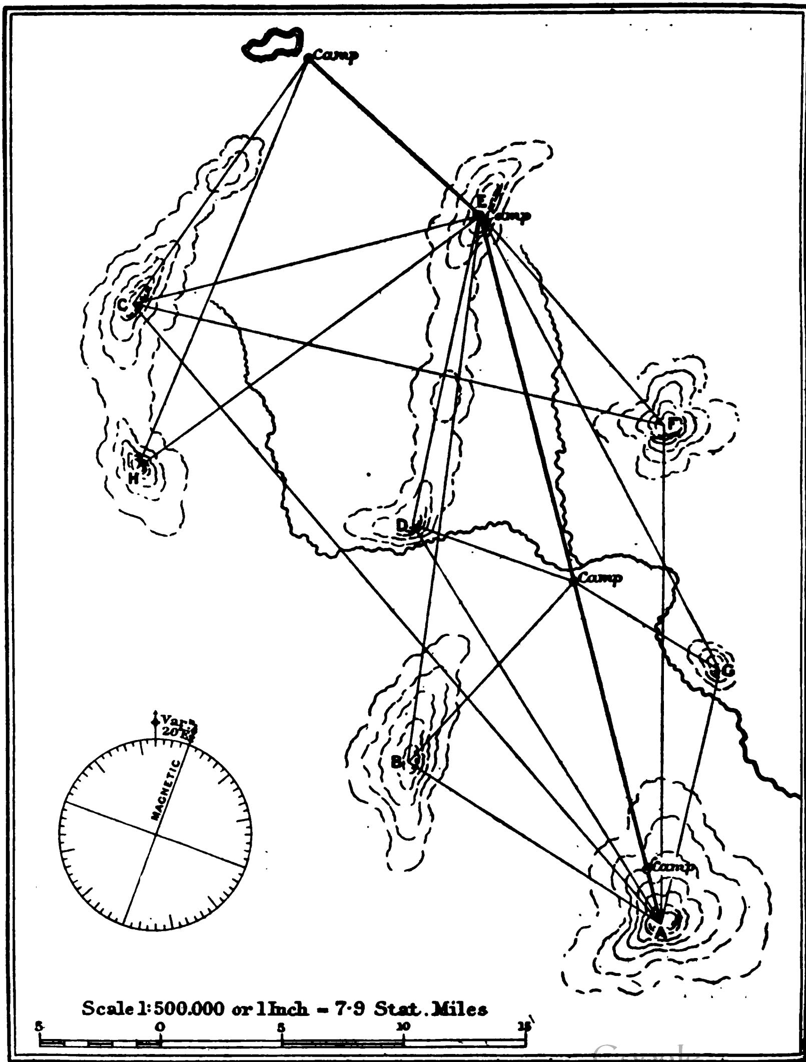


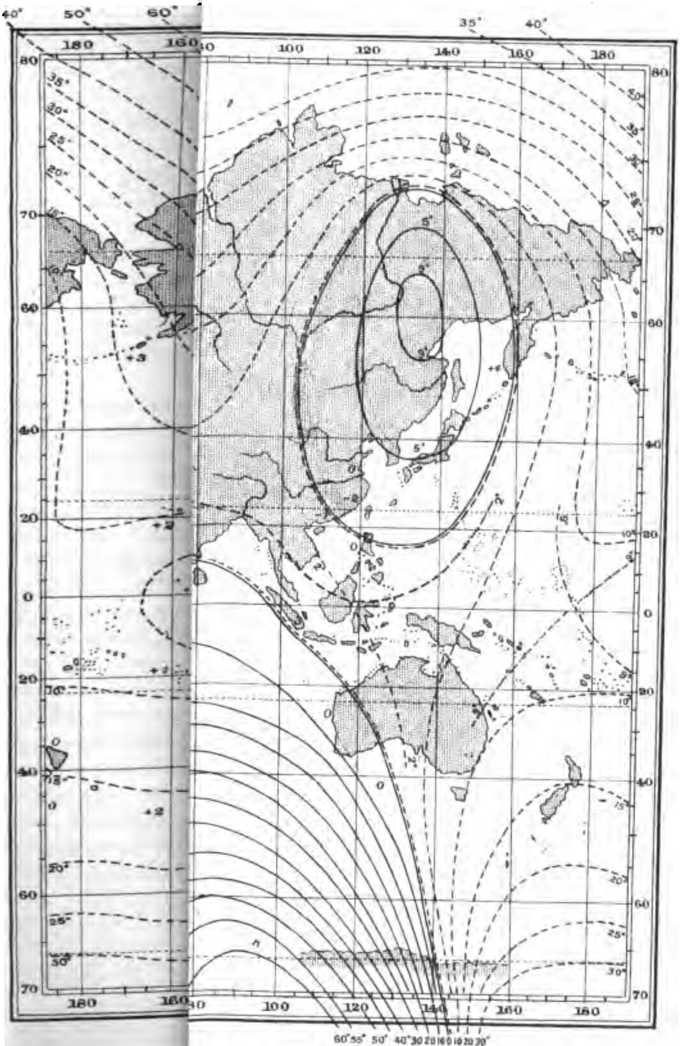
FIG. 63.

and that his estimated distance, by the scale of his map, places him at B in latitude 22° N., but when he observes the meridian altitude of a star he finds that his latitude is really 21° 55′ N., that he has overestimated his distance travelled by the distance C B, and that he really is at C and not at B. If this observation had not been taken he would



Plotting of Compass Traverse.

ARC.



+ indicates an annual increase
– " " decrease

have made B the point on his map to commence plotting his next day's journey, which would have led to considerable errors not only in his latitude and longitude, but also in the positions of the different points he fixed along his route, but by taking C as his starting point he not only corrects his distance travelled, and his latitude, but also corrects his estimated position in longitude. When travelling nearly east or west these remarks would not apply, as the angle between his line of march and the parallel of latitude would be too acute, and his position could only be corrected by such observations for latitude and longitude as are given in the portion of this book devoted to those subjects.

The bearings given in the journal have been laid down on the annexed map, corrected for 20° easterly variation, and will serve to illustrate the manner in which this portion of the work is done.

In the preceding example of a route traverse the information has been recorded in diary form, but it is preferable to keep a field book for a prismatic compass survey, and the specimen given on p. 164 is a convenient form. The centre of the book is ruled into three columns: the first gives the times occupied in passing from one point to another, the centre one the bearings, and the third the approximate rate of travelling in miles per hour. The times combined with the rates give the distances, by simple proportion, which in plotting are taken off the scale of miles, and the compass bearings, of course, give the directions. Where two times are recorded and bracketted at a station, the first, or lower, is the time of arrival, and the second, or upper, the time of departure; so in plotting it must be remembered that the interval between the two must be entirely omitted. This is the usual way of recording, and afterwards plotting by co-ordinates, or more roughly, by means of parallel ruler and protractor, a prismatic compass route survey; and considering the rough character of the work, it is surprising what degree of accuracy can occasionally be obtained by an experienced surveyor under favourable circumstances, especially when the work can be checked by fixed points.

Specimen of Field Book of Prismatic Compass Traverse.

	h. m.	° ′	Miles per hour.	
		F KAMURA.		
Back Bearing to Buro Mt. 167° 30′	2 58	306 0		
			2·75	
		E		
	1 40 1 31	46 30		Bearing of hill 91° 30′
River crossed running W.	12 7			
			2·5	
		D		
	10 55 10 47	301 0		
			2·75	
		C		
NOTE.—When the route passes through thickly wooded country the bearings will necessarily be taken at much more frequent intervals of time than shown here.	9 5 8 57	0 30		Bearing of hill 55°
			2·75	
		B		
	7 30 7 26	312 30		
			2·5	
		A		
F B to Kamura 347° 30′	6 0	BURO MT. June 17 1905.		Bearing of hill in distance 27° 30′ Back Bearing to last Camp 139°
	h. m. *Times.*	*Magnetic Bearings.*	(Miles per hour.) *Rates.*	

The sketch (Fig. 64) shows the plotting of the preceding Prismatic Compass Traverse from the Field Book, also the method of correcting the traverse by latitude and azimuth. (Variation of compass, 8° 30′ W.)

In travelling through thickly wooded country, along a winding native path, where no distant points are visible, and the path is continually changing its direction, the bearing of the short visible sections of the path can alone be recorded, and the bearings would naturally be far more

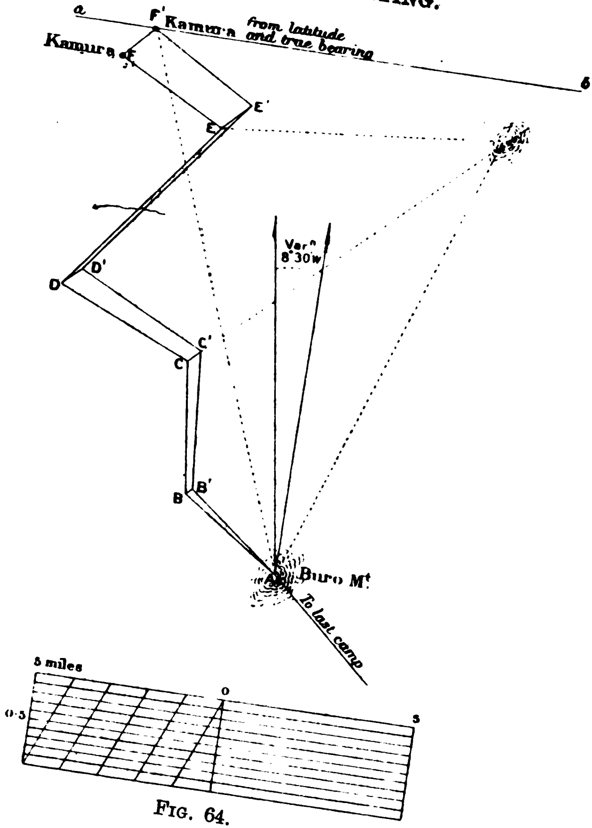


FIG. 64.

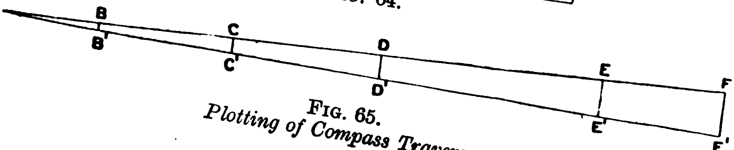


FIG. 65.
Plotting of Compass Traverse.

frequent than those shown on the specimen of the field book. It is often unnecessary to stop at the stations so long as stated here, but where notes of the character of the country, villages, etc., have to be made a reasonable time would be allowed. Where only the bearing has to be recorded, there need be no appreciable delay.

It is often quite impossible to note every slight change in direction, and a general mean has then to suffice. When there is no other means of noting change in direction, the traveller's shadow has at times been found useful, or the direction of the route may be approximately obtained by the watch, as described on p. 81.

It is of the greatest importance that the compass traverse should be checked and adjusted by fixed points. When no points have been previously determined the surveyor should do the best he can to take astronomical observations for latitude, azimuths, and chronometric differences of longitude.

Graphic Method of Distributing Errors in Prismatic Compass Traverse.—If a position obtained by astronomical observation does not agree with that resulting from the compass plotting, the latter, and the route up to that position, must be corrected. An example of a useful method of doing this is given in the plotting on p. 165.

Before leaving Buro Mt. (A) an observation for latitude was taken with a theodolite or sextant, and the true bearing or azimuth of the village Kamura, F′, was also observed, as shown on pp. 258–263, or if no other means is possible it could be found approximately by taking a careful magnetic bearing and applying the variation of compass. Then, on arriving at Kamura F′, an observation is taken which determines the latitude of the place. Now it is clear that the line A F′ represents the true bearing of F′ from A, and the line *a b* the latitude observed. Where these two lines cut is the correct position of F′, Kamura. But by the compass traverse the position of Kamura is at F, hence this latter is evidently in error, and must be corrected, and the whole course of the route from A must be adjusted to this new position, which can be done graphically. Supposing there is no reason to believe that the error exists in one point more than another, all that can be done is to distribute the error proportionately throughout the entire route as follows:—

Connect F F′ by a straight line, and through the other stations E, D, C, B draw lines parallel with this line. Then (Fig. 65) in any

convenient position draw a straight line A F, and working back from F on the route with a pair of dividers, set off on this line the distances F E, E D, D C, C B, and B A., as shown. From F (Fig. 65) set off a line, equal in length to F F′ (Fig. 64), meeting another line, A F′, drawn from A at a right angle. Then from E, D, C, and B drop perpendiculars on to the line A F′ as shown, and taking the measures of these perpendicular lines in the dividers, set them off on the lines through each of the stations on the route drawn parallel to F F′. These lines will be E E′, D D′, C C′, and B B′, and the points E′, D′, C′, and B′ will be the corrected positions of these various stations on the traverse, which connected by straight lines will give the route as adjusted. The position of the hill K will also have to be corrected.

This is a simple and very useful graphic method of distributing the error, and is of course applicable to any kind of traverse or route survey; but when there is much detail on the map the best way of correcting is by the "squaring-in" method, which is well known to draughtsmen. In the present case this would consist of erecting rectangular figures on both the diagonals F A and F′ A, and then ruling each of these into the same number of small squares. All that portion of the route and the mapping included in the squares on F A would be copied by eye into the corresponding squares on F′ A.

Hints on Use of Sextant in Surveying.

(*For the description of this instrument, see p.* 44.)

To measure the Angular Distance between two Terrestrial Objects.—When the horizontal angles between terrestrial objects have to be taken with the sextant, the index is set to zero (0°), and the instrument must be held in the right hand in such a manner that its plane is parallel to an imaginary line joining the two objects; put back all the dark shades, and, looking through the telescope collar and the horizon glass at the *right* hand object, unclamp the index and move it slowly forward until the reflected image in the mirror of the horizon glass coincides with the other object seen directly; clamp the index and make the coincidence perfect with the tangent screw, then read the angle. Make it a rule to commence taking the angles from the object farthest to the right, then from the next farthest, and so on, always working from right to left.

By so doing mistakes will often be prevented in plotting the work, and it will be possible to recognise the objects from which angles have been measured in the rough sketch. Avoid very large or very small angles, as they may cause considerable errors in the positions assigned. Should it be required to measure the horizontal angle between two objects, one of which is at a considerable elevation above the other, as a tree on a plain and a mark on the top of a hill, it will be necessary to select some object immediately below the mark on the hill, and as nearly as possible on the same level as the tree, and measure the angle subtended by them. If no object in a suitable position can be seen, select some point about 90° or 100° from one of the objects, and observe the angles between each object and that point; the difference between these two angles will be the horizontal angle, nearly. Should the angle be too large to be taken in one measurement, the object to the right must be brought by reflection to some well-defined mark, and the reading taken; the angle must then be measured between the mark and the other object; the sum of these readings, after the index error for each measurement has been applied, will be the angle required. Though the angles measured with the sextant are seldom, strictly speaking, the true horizontal angles, yet the errors arising from their obliquity are extremely small, if they have been well chosen, and indeed would be scarcely discernible, in work plotted with the ordinary protractor, which is only divided to 30′. A reference to the following diagrams will, it is hoped, make the previous remarks on this subject more clearly understood.

In Fig. 66 let A B be two objects, O the place of the observer; then the objects would appear in the horizon glass as shown in Fig. 67, when the angle was taken; A being seen in the mirror, B by direct vision through the unsilvered part. If the angle A O B had to be taken by two measurements, A O C would have to be taken first, and then the angle C O B; the sum of these two angles, which is the angle A O B, is the horizontal angle between A and B′, very nearly, because B is directly beneath B′, and is more nearly in the same horizontal plane as A. When a box sextant is used the reflected image is seen above the object by direct vision. In Fig. 68, if the horizontal angle between A and B had to be measured, select a point such as C, more than 90° from A, and at O, the place of the observer, take the angles A O C and B O C; the difference of these two angles will be more nearly the horizontal angle between A B at O, than the angle A O B.

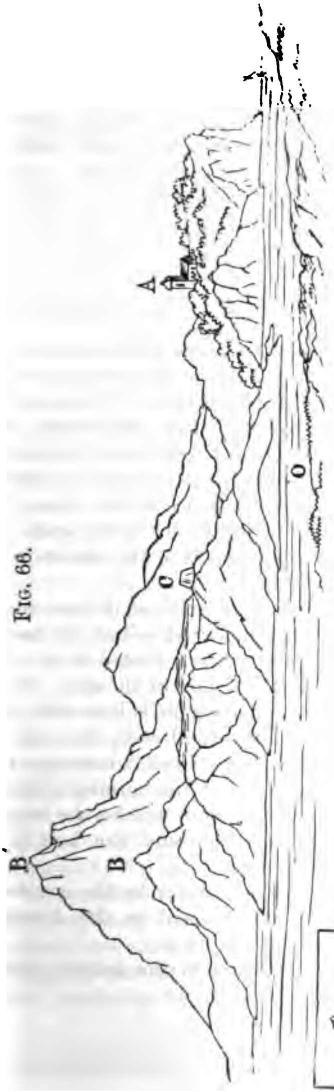


Fig. 66.

Fig. 67.

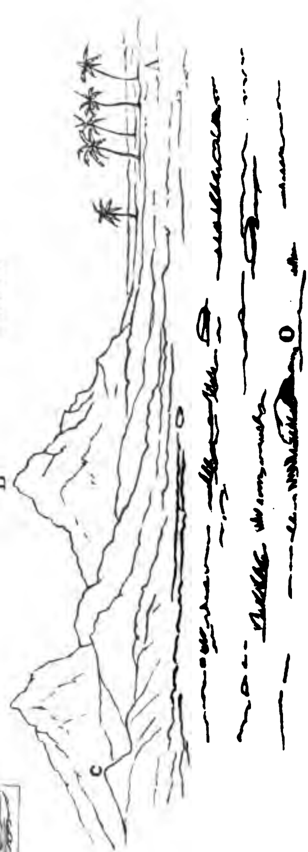


Fig. 68.

TABLE FOR ASCERTAINING HEIGHTS AND DISTANCES BY THE SEXTANT.

Mul.	Angle.	Angle.	Div.
	° ′	° ′	
1	45 00	45 00	1
2	63 26	26 34	2
3	71 34	18 26	3
4	75 58	14 2	4
5	78 41	11 19	5
6	80 32	9 28	6
8	82 52	7 08	8
10	84 17	5 43	10

The sextant being set to any angle contained in the above Table, any height or distance of accessible or inaccessible objects may be obtained in a very simple and expeditious manner. Make a mark on the object, if accessible, to the height of the eye; set the index to any angle from the Table, and advance or go backwards from the object, until, by reflection, the top of the object is brought by the mirrors to coincide with the mark first made. If the angle be greater than 45°, multiply the distance to the object by the number in the next column to the angle in the Table; if the angle be less than 45°, divide, and the result will be the height of the object from the mark; to which add the height of the eye.

If the object is inaccessible, set the index to the greatest divisor angle in the Table that the least distance from the object will admit of; move backwards and forwards until the top of the object is reflected level with the eye; at this place set up a staff equal to the height of the eye. Then set the index to any of the lesser angles; go back in a line with the object, until the top is made to appear on the level with the top of the staff; fix here another mark; measure the distance between the two marks set up; divide this by the difference of the numbers corresponding to the angles made use of, and the quotient will be the height of the object from the top of the staff; to which add the height of the eye.

For the distance.—Multiply the height of the object by the numbers against either of the angles used, and the product will be the distance of the object from the place where such angle was used.

If the index is set at 45°, the distance is equal to the height, minus the height of the eye.

At a given point to mark off a line perpendicular to any given direction.—If the direction is not sufficiently distinguished by some natural object, such as a tree, mark it by a flag set up as far off as convenient; then, standing at the given point, with the sextant set to 90°, make a man, bearing a flag, stand in a line estimated as the perpendicular. Motion him right or left until his flag can be seen, by reflection, to coincide with the other. There let him fix his flag, so marking the direction of the perpendicular.

Of course any other direction can be marked in the same way, setting off the required angle on the sextant, instead of the 90°.

Photographic Surveying.

A great deal has been written in recent years about photographic surveying, and there is no doubt that there are times when the geographical surveyor in little-known regions might find the method extremely useful for filling in topographical detail between points fixed by triangulation or plane table. It is specially adapted to mountainous districts for supplementing the plane table work, as occasionally a mist will clear and render the distant peaks and ranges visible for a short time only—not long enough for survey work by ordinary methods to be carried on. Then if a few photographs can be taken with a surveying camera they will be most valuable for filling in the map. It must not however be supposed that photographic surveying will ever take the place of triangulation or even plane table work, and it should only be used to supplement the work done by the ordinary methods, and even then great care is necessary to ensure good results. In principle photographic surveying is very similar to plane table surveying, but by the latter rays are drawn on the board to the points themselves and the map is constructed in the field, whilst in the former photographs only are taken in the field, and the plane tabling done from these photographs by a draughtsman in an office afterwards. It stands to reason that there are many chances of error creeping in which would not occur in ordinary methods.

Many forms of surveying cameras have been constructed, some of them revolving by clockwork, so as to take the whole panorama on

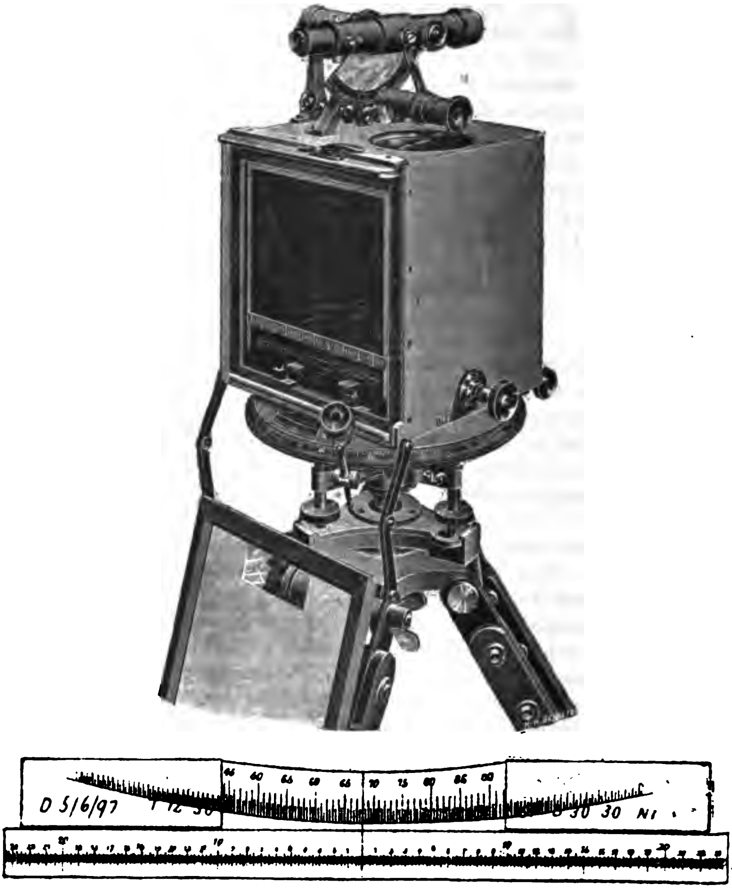


FIG. 69.—*Bridges-Lee Photo-Theodolite.*

one long strip, and others in the form of an ordinary camera, taking views round the horizon in different sections. To the latter class belongs the Bridges-Lee Photo-Theodolite, which, as its name implies, is a combination of a camera and theodolite. This instrument, shown Fig. 69 (from 'Engineering'), is perhaps the best form of surveying camera for the geographical surveyor, although the theodolite part of it is too small to be of much use, and not accurate enough to take the place of the ordinary transit theodolite. The instrument, which is made by Casella, and Troughton & Simms, is, moreover, expensive, costing from £45 to £50. It might be well if it could be arranged for a surveyor to take the camera alone, without the theodolite fitted to it, especially as any expedition hoping to do reliable work would have to carry a transit theodolite as well for triangulation and astronomical observations. The instrument consists of a fixed focus stand camera, which can be accurately levelled, and is so arranged that the photograph, in addition to giving an excellent view of the country, shows the principal vertical plane A B (Fig. 70), the horizontal line C D, and where these two intersect, E, the principal point of the perspective. There is also a compass ring F, attached to the instrument, so that the magnetic bearing of the central vertical line A B is given directly on the picture, whilst that of other points can be obtained by reference to the tangent scale G. Records of barometer, date, time of day, etc., can also be automatically made. The whole apparatus is so constructed that when it has been accurately levelled the principal optical axis of the lens must be truly horizontal, and the back frame, against which the dry plate will be pressed, will be vertical and at right angles to the principal axis.

To use the Bridges-Lee photo-theodolite set it up at some fixed station, if such can be found, and then, after carefully levelling it and selecting the view so as to include the points it is desired to fix, release the compass, and when it comes to rest, focus, insert the plate and make the exposure as directed in the instructions supplied with the instrument. The camera can be revolved and photographs taken from any one station all round the horizon, if necessary. Before leaving a station a record should be made in a note-book of all facts likely to be of assistance in constructing the map later on. It is of course necessary, in order to fix points, that they must be visible from at least two stations, and that to

insure accurate fixing the angles should not be either very acute or very obtuse. Moreover, it is a great assistance if the photograph includes several points of which the positions have been accurately determined. Having completed the work at one station, proceed to another, and repeat

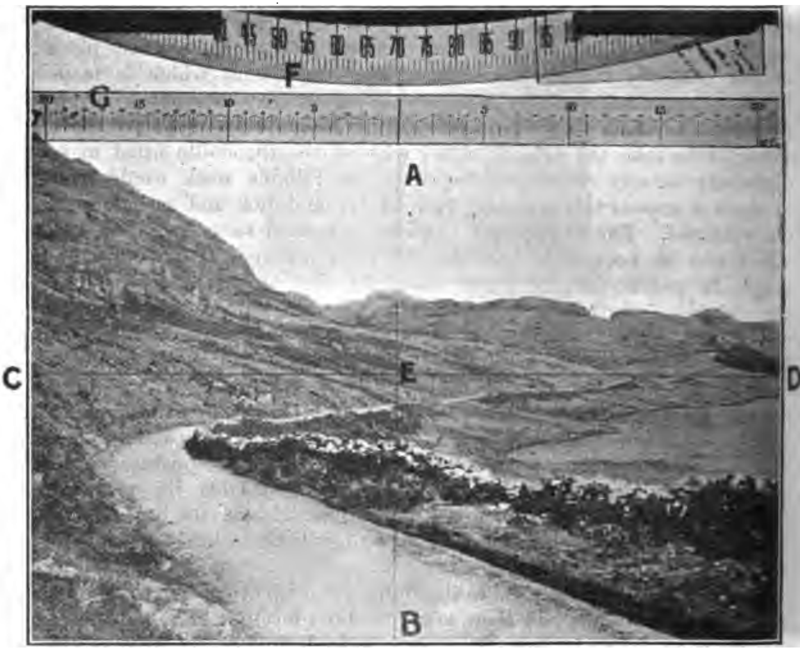


Fig. 70.

the operation; or if no such station can be found, proceed to some position from which the points taken in the photograph at the first station can be seen again, and take a fresh photograph from here, trusting to the fixing of the station later on from the photograph and the points it contains, combined, if necessary, with the compass bearing.

Before making use of the photographs in the construction of the map it is well to have them enlarged three or four times. Next determine the equivalent focal distance for each picture, which can be done by multiplying the length of any suitable distance measured in inches along the tangent scale from the central vertical line shown on the photograph, by the co-tangent of the angle corresponding on that scale to that length. Now mark on the photographs the points that are desired to be fixed, giving each point on all the photographs on which it occurs the same number, and take a strip of paper and mark these points off upon a horizontal line according to their distances from the central vertical line.

Having plotted the fixed points in their correct relative positions on the paper upon which the map is to be drawn, proceed to lay down in their proper position and orientation the horizontal lines with the points marked on them, as follows: Set off from the station marks the correct directions of the distance lines of the views, or the direction of the intersection point of the vertical and horizontal lines, with a protractor, prolonging these lines from the stations until they are equal in length to the equivalent focus of each picture. Now, at their proper focal length, place the centre of the strip of paper with the horizontal line and position mark on the line drawn from the fixed station at right angles to this line, and draw lines from the station through the points to be fixed. Repeat this operation from any other fixed station, and where a line drawn through a point from one station intersects one drawn through the same point on another strip of paper from another station, is the position of that point on the map.

Where the true horizontal line is shown on the photograph, it is also possible to obtain approximate differences of height between the points, when the distance is known, from the formula $h = d$, tan a, d being distance in feet, a the angle, and h the height in feet. Fig. 70 is reproduced from a photograph taken in North Wales with a Bridges-Lee camera.

Photographs taken with a good ordinary camera, which can be correctly levelled, are often of considerable value in filling in the topography on maps, especially of mountainous regions, although naturally the results can only be approximate. The manner of using these is very

similar to that already described, but it is first necessary to ascertain the focal length of the lens, which should be furnished by the maker, or failing this, can be measured.

The photographs should not be cut, so that the centre of the picture may represent the position of the ray passing through the centre of the lens, supposing the camera to have been levelled. Then to use the photographs for filling in the map proceed as follows:—Upon a sheet of paper plot, in their correct relative positions, the fixed stations A B, from which the photographs were taken, and C, another fixed point on the photographs (Fig. 71); and from A draw a line A x equal to the focal length of the

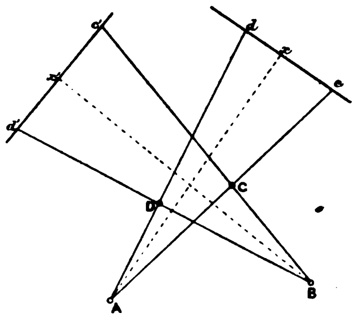


FIG. 71.

lens; at x set off a line with the points from the photograph to be fixed as before at right angles to the line A x. Let c be the representative of the fixed point C on this line. Repeat the operation from B, and let c' be the representation of the same point C taken from B. Now it is clear that if it be desired to fix the position of a peak, such as that shown by d and d' on the two horizontal lines, from the photographs, all that is required is that lines should be drawn from the stations A and B to d and d', and where they intersect at D will be the position of this peak upon the map. Any other points can be fixed in the same way, but it is important to remember that the points on the photographs must be brought to the same horizontal line before plotting.

DETERMINATION OF HEIGHTS.

Levelling.

Accurate levelling and contouring are lengthy and laborious processes, and must be generally left to a time when a regular trigonometrical survey of the country can be carried out. However, sometimes it is desirable that the geographical surveyor should make a detailed plan on a large scale of a special district, in which the exact difference of level is of the greatest importance. To run a line of levels between two stations with accuracy, great care and special precautions are necessary. The instrument generally used is a "Dumpy" level, which consists of a telescope, with cross-hairs, attached to which is a long and delicate level and a compass. It is fitted to, and can be revolved upon, a tripod-stand, similar to that of a theodolite. The ordinary theodolite may be used as a "Dumpy" level, in which case it is preferable, though not necessary, to have an additional level upon the telescope.

In conjunction with the level are used levelling staves, usually 14 feet long, closing telescopically in three joints, and clearly divided into feet and decimals of a foot. A measuring tape is also required for obtaining the distances between the staves along the line to be levelled.

Briefly, the operation of levelling is as follows:—

Suppose the spirit-level to be set up at A (Fig. 72), directed on the levelling staff at B, and the figure noted which is cut by the horizontal hair. This figure would be the difference of level between A and B, minus the height of the telescope above the ground (which might be measured and deducted). If the distance between the points were under 300 or 400 yards, the correction for curvature and refraction would be inappreciable.

Suppose another staff were held at C and the telescope directed on it, the difference between the readings of B and C would evidently be the difference of level between these points, independently of the height of the spirit-level above the ground, common to both; and if C and B be equidistant from A, they would be equally affected by curvature and refraction, which might therefore be ignored. Any error of collimation in the telescope would also be common to both observations, and would be eliminated in the same manner. The levelling staff might also be held

at F, G, etc., and the readings noted. It would then only be necessary to measure the horizontal distance between these points in order to obtain the data for drawing a correct section of the ground. If it were required to continue the levelling beyond G, the spirit-level would be carried forward and placed in such a position H, and at such a height that it might intersect some part of the staff at G, care being taken not to alter the position of the foot of the latter meantime, but merely to turn it with its face towards the spirit-level.

In the operation represented (Fig. 72), the levelling commencing at F

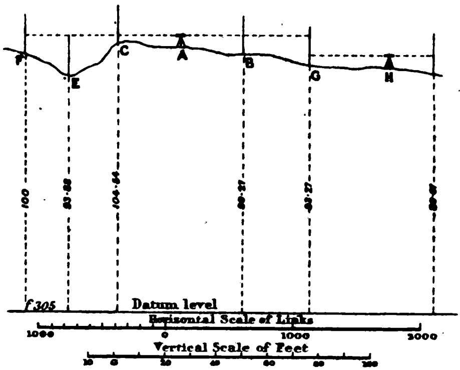


FIG. 72.

and proceeding forward to the right, F would be called the back staff, G the forward staff, and E, C and B would be intermediate.

On setting up the level at H, G would become the back staff, those to its right would be intermediate, and the last place at which the staff could be held, before it would be necessary to carry the spirit-level on, would be the forward staff.

The spirit-level must be placed with judgment in such a position as to command a good view of the ground over which the section passes; it need not, of course, be placed on the line, but it should be nearly equidistant between the places of the back and forward staves.

The following form of levelling field book will be found generally convenient:—

Station.	Back Reading.	Inter-mediate.	Forward Reading.	Height of Instrument.	Reduced Level.	Remarks.
F	6·52	..	..	106·52	100·00	Assumed
305	..	12·64	..	..	93·88	
642	..	1·98	..	..	104·54	
1,680	..	7·25	..	..	99·27	
2,193	3·15	..	13·25	96·42	93·27	G
140	..	6·75	..	..	89·67	

The readings from F to "forward reading" at G are read from A, remainder from H.

When the back reading is greater than the forward, the latter must evidently be the higher ground.

The distances of all intermediate points are measured from the starting point.

As to the column "Reduced Levels," it is usual to assume a datum level, or imaginary line, to which all the vertical measurements are referred. The entries in this column show the heights with regard to this line. It is convenient that the datum level should be lower than any part of the section, so that all the measurements may be taken above it, as shown in Fig. 72.

In the Ordnance Survey of England the datum to which all the altitudes refer is the height of mean tide at Liverpool.

The height of F in the above register is assumed at 100, and in the column "Reduced Levels" the height of each point is obtained by addition to, or subtraction from, the "reduced level" of the back staff.

The reduced level of a forward or intermediate station is found by adding the "back reading" to the "reduced level" of the station on which the back reading is taken (shown in column "Height of Instrument") and subtracting the intermediate forward reading from this.

The staves are called "back" and "forward" in reference to their relation to each other on the section line, not as regards the spirit-level, which might be before or behind both.

In measuring the distances the deduction due to the degree of slope should be made before entering them in the register.

Levelling with the Theodolite.—Sections of ground may be taken with the theodolite more expeditiously, though less accurately, than in the manner described with the regular spirit-level. Thus:—

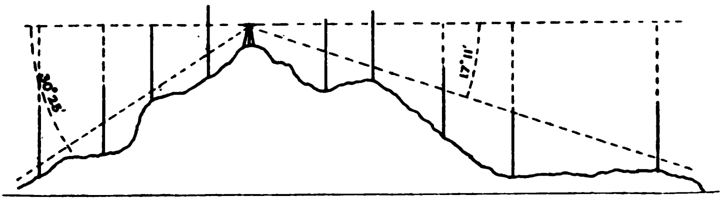


FIG. 73.

Let the theodolite be set up as shown in the figure (Fig. 73), and its telescope directed parallel to the general slope of the hill. Observe this vertical angle with all precautions for accuracy proper to the operation.

Keeping the telescope clamped in this position, note the successive readings of a levelling staff held by an assistant at the various points which will best define the irregularities of the section; the height of the theodolite and the horizontal distance between these points being measured, a section can be drawn thus:—

Draw the horizontal line passing through the telescope. Protract the observed angle of inclination (as shown in Fig. 73). On the horizontal line set off the measured distances to scale. Draw perpendiculars from these to the hypothenusal line. Beneath the points thus found set off the staff readings, being the level of the ground where the foot of the staff stood for each observation.

Should the staff be so distant that the markings are illegible, a system of signals can be agreed upon, so that the assistant can move a visible mark along the face of the staff until signalled correct; the assistant can then note the reading.

Contouring.

It is not only necessary that the position of places should be accurately determined and laid down upon a map, but also that the general relief of the ground and topographical features should be clearly indicated. There are several ways of showing the relief, such as by hill shading with a brush or pencil, or vertical or horizontal hachuring; but the most accurate is by a regular system of contour lines at definite intervals apart. This method, however, occupies considerable time, and the geographical surveyor in a new country generally has to content himself with fixing as many heights as possible by theodolite angles or barometer, and then showing the mountains and hills by approximate contours controlled by the fixed heights. The vertical interval between the contours necessarily depends upon the scale of the map; for a map on one mile to an inch, it should be 50 feet; for two miles to an inch, 100 feet, and so on; or, simply expressed, the interval between the contours is $\frac{50}{\text{inches to a mile}}$. This rule practically applies also for the scales of $\frac{1}{125,000}$, $\frac{1}{250,000}$, etc.

Space does not allow in these 'Hints' of a detailed description of the different methods of contouring, but as it may occasionally be required to draw a plan on a large scale, such as the site of ancient ruins, a battle-field, etc., a few practical instructions are given.

First make an outline plan of the area to be contoured, preferably with the plane table, in the ordinary manner, and then, starting from some definitely fixed height, level up or down from this to some position on the ground A (see plan, p. 184), where the height is an even number, as 350 feet. From this point set off rays A B, A C, etc., on the plane table in all directions up or down the principal ridges and depressions on the ground, and along these lines run a line of levels, either as shown on p. 178, or more approximately with an Abney level, fastened on the top of a rod of known length, and mark off on the ground the points of equal vertical interval, as every 4 feet. Then remove the plane table to other positions suitable for obtaining the leading features of the ground relief, as C, E, I, etc., and after orienting the board, draw fresh rays, as C J, C K, etc., and again set off the points of equal vertical interval.

Measure the distance between these points on the ground and mark

them off on the plan. When the degree of slope exceeds 3° the measured distance should be brought to the horizontal distance before plotting the points by the ordinary method, or from a scale constructed as shown on the plan (p. 184), which is useful in the field for large scale work, as it renders it possible to obtain the horizontal distance from the distance measured along the slope and the angle of the slope without any computation. To do this, take the measured distance from the diagonal scale; then with the leg of the compasses at X on the protractor drawn upon the scale, set this distance off as the hypotenuse X *z* of a right-angled triangle upon that degree line which will have the vertical interval *y z* as its perpendicular; then the base of the triangle X *y* will be the horizontal distance.

A Dumpy level or a theodolite is best suited for obtaining the levels, but when only an Abney level or an ordinary clinometer is available, fasten it on to the top of a 4-foot rod, so that when the index points to 0° and the level bubble is in the centre of the run, the rod is exactly perpendicular. Then walk down the line of one of the rays on the plane table until, with the rod perpendicular, the starting-point on the ground, as A, is seen on the horizontal cross-line of the level telescope. Repeat this operation all along the line of the rays. These points will all be at equal vertical intervals of four feet apart, and on the line A D they are represented by *a*, *b*, *c*, etc. According to the rule given on p. 181 4 feet is, in round numbers, the vertical interval for contours on a plan drawn to the scale of 1 : 5,000, and the interval for any other scale can of course be obtained by proportion. In the case of a smaller scale it would not be necessary to mark off every point of rise or fall shown by the rod; only every other one or every fourth, as the case may be.

Having obtained the levels or points of equal vertical height along the rays, and marked them off on the plane table plan, connect all the points on the different rays having the same vertical height by drawing curves, and the result, if care is taken, is a fairly correct contoured plan of the district; but of course the accuracy depends in great measure upon the number of rays and their selection.

Elevations above each station, A, C, E, H, etc., where the plane table is set up, should be marked by a + sign, and depressions below it by —; this will save confusion when drawing the contour curves later on.

A contour plan of a district can of course be made without a plane

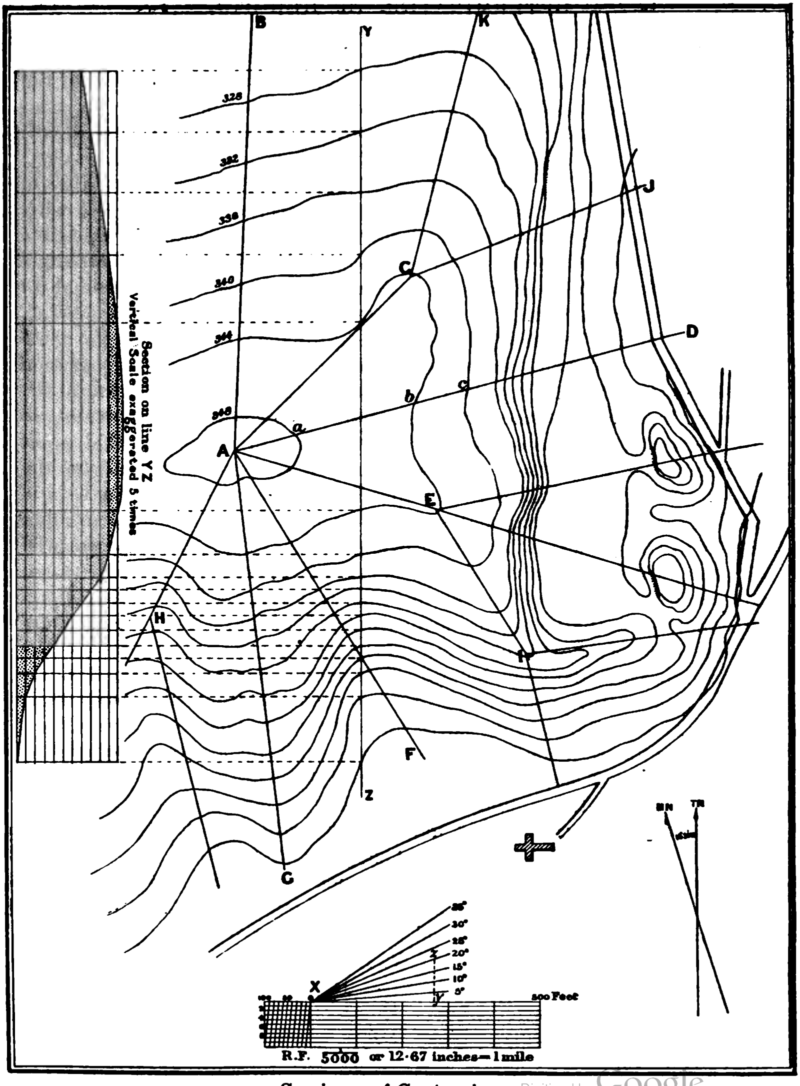
table, by recording the horizontal angles between rays taken with a theodolite or other instrument, and the angles and distances between the contours in a field book and plotting afterwards; but the plane table is decidedly the best instrument for this purpose for the geographical surveyor.

The method of contouring previously described, although capable of considerable accuracy, is a somewhat lengthy operation, and the following more rapid process is therefore often the only one possible in the time available. With an Abney level or clinometer, observe the general angle of elevation or depression up or down the slopes of the ground in sections, so far as they may be considered approximately the same, allowing for the height of the eye by sighting on to a rod of the same height as the eye, and then measure the distance on the ground between these points. Now, using the protractor or scale of slopes shown on the plan (p. 184), mark off the measured distance on the line corresponding to the degree of slope observed, say 5°, and drop a line from this point perpendicular to the base of the right-angled triangle, or 0° line, on the scale. Take the length of this perpendicular line in the compasses and measure it upon the diagonal scale, and this will give the total number of feet in the vertical difference of height, or rise or fall, for the measured distance, which number, divided by the adopted Vertical Interval between the contours, will give the number of contours to be marked off on the plan upon the slope in the measured distance, whilst the measure of the base of the triangle cut off by the perpendicular will be the horizontal equivalent, as before. Proceeding in this manner, a fairly accurate contoured plan on a large scale can be drawn in a very short time. This method is only suited for large scale plans.

Protractors are made giving the Horizontal Equivalents corresponding to any degree of slope for stated Vertical Intervals, and when such are available they will be found most convenient.

Another, and perhaps the most usual method of approximate contouring is to measure the angle of slopes with a clinometer, and then from the following ordinary formula plot the distance or Horizontal Equivalents between the contours on the plan for the known Vertical Interval. This rule does not hold good for angles over 20°.

$$\text{H. E.} = \frac{\text{V. I.} \times 19{\cdot}1}{\text{D}}$$



Specimen of Contouring.

where H E equals the Horizontal Equivalent or horizontal distance between the contours in yards, V. I. the Vertical Interval between the contours in feet, and D the Degrees of Slopes. This formula by transposition becomes—

$$\text{V. I.} = \frac{\text{H. E.} \times \text{D}}{19 \cdot 1}, \text{ and } \text{D} = \frac{19 \cdot 1 \times \text{V. I.}}{\text{H. E.}}$$

Vertical sections through any district can be readily made from a contoured plan, as shown on the annexed plan, but it is usually necessary to exaggerate the vertical scale. This however should not be done more than necessary, and should always be an even number of times.

Determination of Differences of Heights by Theodolite Vertical Angles.

Levelling and accurate contouring are necessary for detailed work on large scales, but are both lengthy processes, hence the methods of determining the difference of height between two places suited to the geographical surveyor generally depend upon triangulation based upon vertical angles, or upon the difference of atmospheric pressure.

The former gives the most satisfactory results, but requires that the vertical angles should be accurately measured with the theodolite, and that the distance to the peak or point on the ground to be fixed should be known. The angles should be taken F L and F R, and corrected for level error as shown pp. 42–44.*

The geographical surveyor, furnished with a 5-inch micrometer transit theodolite, ought to be able to rely upon obtaining the correct difference of height between two stations by means of vertical angles within a very few feet.

In the figures p. 186, let the line H R be the horizon at A, and H′ R′ the horizon at B. Let E be the angle of elevation, and D the angle of depression.

* In correcting vertical angles for level error it must be remembered that in depression angles the rule for applying the correction is the reverse of that for altitude, *i.e.*, when the sum of the E. readings exceeds that of the O. readings it is +, and when the reverse is the case, it is −.

There will be three possible cases of this method—

(1.) Where vertical angle E alone is measured at A.

(2.) Where both the elevation angle of B from A (E), and the depression angle of A from B (D), are measured.

(3.) Where both the angles at A and B are measured, but, owing to the effect of curvature, which is to lower the object, exceeding that of refraction, which raises the object, both angles are depressions.

In the first case (1) if H R be the horizon, and E the angle of elevation, it is clear that a considerable amount of the peak B would be cut off by

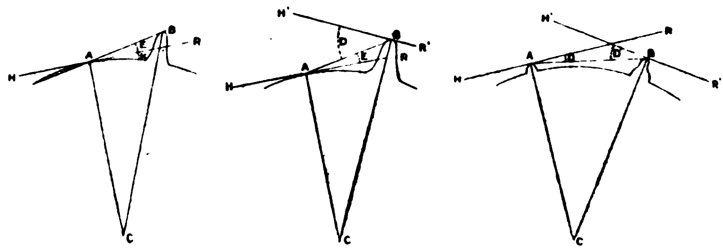


FIG. 74.

curvature, which exceeds the effect of refraction, and to compensate for this a correction, K, has to be added to the angle before computing the difference of height.

ADOPTED REFRACTION EXPRESSED IN DECIMALS OF CONTAINED ARC.								
0·20	0·10	0·09	0·08	0·07	0·06	0·05	0·04	0·03
2·5284	2·4034	2·3927	2·3822	2·3720	2·3620	2·3523	2·3427	2·3334

NOTE.—If nothing is known of the Refraction, adopt 0·07 as the value of it.

This table (p. 186) is to facilitate finding the subtended angle when only one angle has been observed:—

$$\left.\begin{matrix} D_a \\ E_a \end{matrix}\right\} = \text{angle of } \left\{\begin{matrix}\text{Depression} \\ \text{Elevation}\end{matrix}\right\} \text{ at A.}$$

$$\left.\begin{matrix} D_b \\ E_b \end{matrix}\right\} = \quad ,, \qquad ,, \quad \text{at B.}$$

$$c = \text{distance in feet between A and B.}$$

1st case.—When one angle only (D_a or E_a) has been observed, we must first find the subtended angle—

Rule.—Enter the preceding table with the assumed coefficient for refraction, and subtract the corresponding number from the log of c, the distance in feet. The natural number corresponding to the resulting logarithm is an angle K in seconds of arc, then—

$$S = K - D, \text{ or } K + E.$$

Having now found S in either case, the difference in height in feet (h) between A and B is obtained from the formula—

$$h = c \tan S.$$

Example.

Data.	E_a (vertical angle of elevation at Beacon Hill, A, of Selsfield Tower, B)	$= 0° \; 4' \; 21''$
	log c = log distance in feet between A and B.	= 41260 ft.
	height of A	= 586·36 ft. (Above sea level.)

Log c =	4·615529	
No. from Table, p. 186 =	2·372000	(Taking co-eff. of refactn. = 0·07)*
Diff. = log K =	2·243529	
∴ K =	175·2″	
K =	0° 2′ 55″·2	
E_a =	0 4 21	
$S = K + E_a$ =	0 7 16·2	

* In England the co-efficient of refraction may be taken as ·075 for rays not crossing the sea; ·081 for rays crossing the sea. In India it may be taken generally as ·07. In the dry climate of Afghanistan it is sometimes as low as ·05.

Example—continued.

log tan S =	7·325261	
C = 41260 ft. log =	4·615529	
Sum = log h =	1·940790	
∴ h =	87·25	ft.
Height of A above M S L =	586·36	
Height of top of Selsfield Tower, B, above M S L . =	673·61 *	
Height of Selsfield Tower, B, above level of ground . = −	70	
	603·61	= Height of bottom of Selsfield Tower, B, above mean sea level.

* Where signals are used and it is considered desirable to take their heights into consideration. The correction to height of deduced station B is $\frac{g_a - g_b + i_a - i_b}{2}$, where g_a, g_b are the heights of signals at A and B, i_a, i_b are the heights of instruments at A and B.

When Reciprocal Angles have been Observed.

2nd case.—If one angle only is an elevation, take half the sum. The result is an auxiliary angle called the subtended angle (S)—

$$i.e.,\ S = \frac{D_b - D_a}{2} \text{ or } \frac{E_a + D_b}{2}.$$

3rd case.—If both angles are depressions, take half the difference.

As will be seen from the above formulæ, when reciprocal angles are taken, as in cases (2) and (3), the correction K is not necessary, as, owing to the difference of the inclination of the horizon lines, the effects of curvature and refraction at A and B have opposite effects on the vertical angle, and so counterbalance one another. This will be clear from an inspection of the figures (2) and (3). In case (2), therefore, where one angle is an elevation and the other a depression, take *half the sum* of the two angles as the angle for computation (called S on the form above), but in case (3), where both angles are depressions, take *half the difference.* Then the log tan of the angle S, added to the log of the distance between A and B in feet (called *c* on form), will give the log of the difference of height in feet between the stations A and B.

As already shown in case (1), p. 186, where reciprocal angles have not been observed, it is necessary to adopt some approximate value for the refraction (B A R) (Fig. 75).

From this figure it is clear that, calling the refraction r,

$$r = \frac{c - D_a - D_b}{2},$$

where c is the arc of the earth's surface between A and B.

So that whenever reciprocal angles have been observed, the amount of the refraction can be found.

The result of a very large number of observations all over the world is to show that the quantity $\frac{r}{c}$, called the coefficient of refraction, is fairly constant for a given country and climate. The table, p. 186, is computed on this principle, but when no table is available, it may be necessary to find the coefficient, which can be done as here shown.

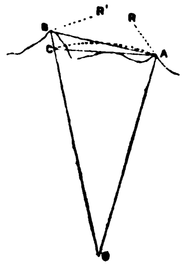


FIG. 75.

When one angle alone is measured, and no tables are available, a very good general rule for correcting heights computed from vertical angles for curvature and refraction is as follows:—*Correction in feet = $\frac{4}{7}$ of the square of the distance between the two stations in statute miles.*

This correction must be added to the difference in height between the two stations, as worked out by adding the log tangent of the measured vertical angle to the log of the distance c, when the measured angle is an elevation, and subtracted from it when it is a depression.

HEIGHT BY BAROMETER AND BOILING-POINT THERMOMETER.

Differences of height depending upon the determination of the difference of atmospheric pressure are all more or less approximate, but the best results are obtained by the mercurial barometer. The simpler the construction of the instrument the better, and the scale should always be divided upon the glass tube itself. The practical difficulty for travellers is that of carrying the barometer, for it is almost impossible to prevent the tubes breaking if taken with the mercury in them, and the ordinary method of filling is of course out of the question under the

circumstances in which the surveyor in rough countries generally finds himself. Captain George's barometer, fully described on p. 63, is perhaps the best, although the process of filling is at times trying, specially at the low temperature of great altitudes.

Ordinary aneroids are quite unreliable for great altitudes, and, indeed, often fail to give anything like good results at 3000 or 5000 feet. Whenever they are employed they should be checked by mercurial barometer, boiling-point thermometers, or some other means. They are, however, useful for intermediate differences of height and for rapid contouring. The Watkin Mountain Aneroid, described on p. 66, has, in the hands of several travellers, proved a decided improvement upon the ordinary form where great altitudes are concerned.

As the temperature at which water boils depends upon the pressure of the atmosphere, the boiling-point thermometer merely measures the difference of atmospheric pressure in another way, and, like the other methods, must not be depended upon for absolute height, although it is certainly more reliable than the ordinary aneroid. Heights determined by boiling-point should not be relied on to within about 150 feet. There is this difference, however, between the aneroid and the boiling-point thermometer, that whereas the former will often have an error which rapidly increases in proportion to the altitude, so that at a few thousands of feet it may be hopelessly wrong, the boiling-point thermometer will, in all probability, not have a much greater error at a great altitude than it will at a lower one.

With each of these instruments it is most important that there should be the "Kew Certificate," and that the corrections should be applied before computing the results. As the errors often change in the course of time, they should always be determined again after a few years.

The following examples and method of computing differences of height from barometer or aneroid and boiling-point thermometer readings, with the necessary tables (Tables X.–XII.), have been arranged by Dr. Francis Galton, F.R.S., and will be found convenient:—

By Barometer or Aneroid.—The small but complete tables (XII.) will be especially useful to those who carry a mountain barometer and are anxious to make accurate determinations, but are not furnished with larger tables. These are calculated by Loomis, and are extracted from Guyot's collection.

Part I. of Table XII. gives the altitude, subject to correction, for the temperature of the air, and for other influences which are the subjects of Parts II., III., IV., and V. of the same Table.

Method of Computation.—(1) Take from Part I. the two numbers corresponding to the two barometric heights; (2) from their difference subtract the correction found in Part II., with the difference between the thermometers that are attached to the barometers, when such exist (*Mem.*: this correction is not wanted for aneroids, for their works are mechanically compensated for temperature); (3) for the temperature of the intermediate air between the two stations multiply the nine-hundredth part of the value already obtained by the difference between the sum of the temperatures at the two stations and 64°. This correction is additive when the sum of the temperature exceeds 64°, otherwise it is subtractive; or, what comes to the same thing, use the multiplier given in Table XI., p. 295; (4) For further precision take corrections from Parts III. and IV., also from Part V. (Table XII.), when the lower station is so high as to bring the case within the range of that table :—

(*Example* 1.)	Upper Station.	Lower Station by Sea.
Thermometer in open air	70°·3	77°·5
Thermometer in barometer	70°·3	77°·5
	Inches.	Inches.
Barometer	23·66	30·046
Latitude 21°.		
Part I. gives for 30·046 inches		27649·7
Part I. gives for 23·66 inches		21406·9
Difference		6242·8
Part II. gives for 77°·5 − 70°·3 (= 7°·2)		−16·9
Approximate altitude		6225·9
$\frac{6225\cdot9}{900} \times (77^\circ\cdot5 + 70^\circ\cdot3 - 64^\circ) = 6\cdot918 \times 83\cdot8$	=	+579·7*
Nearly correct altitude		6805·6
Part III. gives for above altitude and latitude 21°		+13·3
Part IV. gives for above altitude		+19·3
Part V. is not used in this case		0·0
Correct height above sea		6838·2 feet.

* If Table XI., p. 295, had been used, we should have written—

$$\frac{77^\circ\cdot5 + 70^\circ\cdot3}{2} = 74^\circ \text{ nearly.}$$

The corresponding multiplier is 1·0933

$$1\cdot0933 \times 6225\cdot9 = 6806\cdot8.$$

(*Example* 2.)
The Lower Station is in Lat. 30°, 4890 ft. above sea-level.

		Upper Station.		Lower Station.
		°		°
Thermometer in open air	.. ..	32	..	89
Thermometer in barometer	.. ..	35	..	89
		Inches.		Inches.
Barometer	.. ..	15·76	..	25·07
Part I. gives { for 25·07 inches	.. ..	.. ..	..	22919·3
Part I. gives { for 15·76 inches	.. ..	.. ..	..	10791·3
	Difference	.. ..	..	12128
Part II. gives for 89° − 35°	.. ..	.. ..	..	−126
	Approximate altitude	.. ..	..	12002
$\frac{12001 \cdot 6}{900} \times (89° + 32° - 64°) = 13 \cdot 3 \times 57$	.. ..	.. ..	=	+758
	Nearly correct altitude	.. ..	..	12760
	Height of Lower Station	.. ..	..	4890
				17650
From Part III.	.. ..	.. ..	..	22
From Part IV.	.. ..	.. ..	..	56
From Part V.	.. ..	.. ..	..	7
Altitude above the sea-level	.. ..	.. ..	..	17735

For high elevations it is needless to pay attention to decimals.

By Boiling-Point Thermometer.—Enter Table X., p. 293, with the boiling-point at each of the two stations, and extract the numbers that stand opposite to them in the column headed "Altitude, &c." The difference between these numbers gives the difference of height between the two stations, supposing the mean temperature of the intermediate air to be 32° Fahr. The correction for the temperature of the air, when it differs from this value, is given in Table XI. Take the mean* of the thermometers (exposed in shade) at the upper and lower stations, and enter Table XI. with that mean value; and the number that stands opposite to it, in the column headed "Multiplier," must be multiplied with the results obtained from Table X. Thus:—

At station A the boiling-point = 195°·1, tabular number = 9040
,, B the ,, = 210°·3, ,, = 887

Approximate difference of height = 8153 feet.

* This represents more nearly the average temperature of the intervening column of air than any other value that can easily be specified. But it is only an approximation of the truth.

To correct for temperature of intermediate air :—
At station A, temp. of air = 65° Fahr.
„ B, „ = 73° „

$$2\,)\,\overline{138}$$

$\overline{69}$ = mean temperature of intermediate air.

In Table XI. the multiplier corresponding to 69° is 1·082, and 1·082 × 8153 = 8821 (neglecting decimal fractions).

In those rare cases where greater altitudes are dealt with than are included within the limits of the table, the traveller should allow 570 feet for the difference between 185° and 184°; 572 feet for that between 184° and 183°; 574 feet for the next interval, and so on.

When the boiling-point at the upper station alone is observed by the traveller, he sometimes has the opportunity of availing himself of some established observatory at no great distance, to serve as the lower station. A memoir by R. Scott, F.R.S., late Secretary to the Meteorological Office, published with a map in Vol. XI. of the 'Journ. Roy. Meteor. Soc., shows the distribution of stations past and present, over the globe. But these are continually changing, so the intending traveller should seek the latest information at the Meteorological Office, 63, Victoria Street, S.W.

At times, however, the traveller has no option but to take the mean height of the barometer, reduced to the sea-level, in the district in which he is, and for the same season of the year, and to use this in the place of observations at a lower station. He will find what he wants in the maps of mean barometric pressure, reduced to sea-level, that are given in most of the physical atlases ('Bartholomew's Physical Atlas,' Vol. III., is the most recent of these), and also in 'Report on the Scientific Results of the Voyage of the Challenger, during the years 1873–76.' 'Physics and Chemistry,' Vol. II. (The section of this volume on Atmospheric Circulation, by A. Buchan, M.A., LL.D., contains valuable statistical information on thermometric and barometric observations in different parts of the world, and a series of charts of the world showing isothermal and isobaric lines for every month of the year.) When no more complete charts are available, those given opposite p. 50 in the second volume of this work will be found useful. The quarterly charts published by the Meteorological Office refer to the ocean only, but they are preferable whenever the traveller's station is near the coast. It seems impossible to compress the information given by these charts

into a form suitable to these pages, especially as the mean barometric height sometimes varies greatly in neighbouring places. The distance from Takutsk in Siberia to the Sea of Okhotsk is only 500 miles, yet in winter the calculated mean heights of the barometer at these two places, when reduced to sea-level, differ as much as 0·8 inch. From the latitude of Valdivia in South America to Cape Horn, the distance is 900 miles, and the mean difference of barometric pressure is 0·5 inch. Vancouver's Island is another district where the mean barometer differs much at moderate distances.

Whenever the observations at the upper and lower stations are not strictly simultaneous, or when the mean barometer is taken in place of the lower station, the correction for diurnal variation must not be omitted, especially in the tropics, where, in other respects, the barometer is very steady. The mean amount of diurnal variation in different parts of the world is also given in Berghaus' maps. An error of one or two hundred feet might often be caused by the neglect to allow for it.

The traveller cannot be too strongly urged to have his boiling-point thermometers verified both before starting and after returning. Their index error is apt to vary, the thermometer reading lower than it should do after frequent use. This is especially the case for the first few years after they are made.

ADJUSTMENT OF THEODOLITE OBSERVATIONS.

Residuals.—If a number of measurements are made of the same quantity, the sum of the measured values divided by the number of measurements is the *mean*, and a *residual* is the result of subtracting the mean from a measured value.

With a large number of observations the mean tends to become the true value, and the residuals to become errors.

Probable Error.—In an indefinitely large series of errors, the *probable error* is that error than which there are as many errors greater as there are smaller; i.e., the chance that any error taken at random is greater than the probable error is the same as that it is smaller.

The Probable Error of the Arithmetic Mean of a series of observations

$$= 0 \cdot 674 \sqrt{\frac{\Sigma r^2}{n\,(n-1)}},$$

when n is the number of observations, and Σr^2 is the sum of the squares of the residuals.

The probable error is a valuable means of comparing the accuracy of sets of observations of the same class. Thus suppose two observers, A and B, have measured the same angle with the same instrument and have obtained the following results (seconds only are given):—

A. ″	r	r^2	B. ″	r	r^2
47	0	0	48	3	9
49	2	4	46	1	1
50	3	9	49	4	16
42	5	25	41	4	16
48	1	1	47	2	4
46	1	1	39	6	36
Mean 47		$\Sigma r^2 = 40$	45		$\Sigma r^2 = 82$

The probable error of the mean of A's set is

$$\cdot 67 \sqrt{\tfrac{40}{30}} = \cdot 77, \text{ and of B's set is } \cdot 67 \sqrt{\tfrac{82}{30}} = 1 \cdot 11.$$

A's set is thus the most reliable.

The means would be expressed as

$$47'' \pm 0 \cdot 77 \text{ and } 45'' \pm 1 \cdot 11.$$

Owing to the fact that it is very difficult to free observations of any kind from constant or systematic errors, the probable error obtained in this way is better considered as a test of the relative value of similar observations than as a statement of the amount by which the mean of a series is probably in error. Thus the probable error of angles in a geodetic triangulation derived from the inter-agreement of observed values of the angles is generally smaller than that derived from a consideration of the triangular errors.

Law of the Propagation of Error.—The probable error of the sum or difference of two quantities is equal to the square root of the sum of the squares of their probable errors; and so on for any number of quantities. This rule is of frequent use in all kinds of survey work.

As an example, suppose that the probable error of a carefully measured base is $\pm 1 \cdot 2$ inches, and that subsequently an extension is measured with a probable error of $\pm 0 \cdot 7$ inch, then the probable error of the whole base will be $\sqrt{(1 \cdot 2^2 + \cdot 7^2)} = 1 \cdot 4$.

The probable error of the arithmetic mean equals probable error

of a single observation divided by the square root of the number of observations.

The probable error of the mean therefore varies inversely as the square root of the number of observations.

Thus suppose the probable error of a determination of longitude by a single moon culmination is three miles; the probable error of the mean of the result of nine culminations will be one mile.

If the probable error of longitude from one lunar distance is ten miles, it will require 100 lunar distances to obtain a result with a probable error of one mile.

Examples :—

(1) *Latitudes and Azimuths.*—Suppose that it is found impossible to measure a base directly, and it is decided to use one determined by latitudes at two stations and the observed azimuth of the ray between them. It is required that this base shall have a probable error not greater than $\frac{1}{500}$. The azimuth of the ray is about 45°, how long must the ray be?

The probable error of each observed latitude is about 1″, say; the probable error due to local attraction is about 2″; the probable error of the difference of the two latitudes will therefore be

$$\sqrt{(1 + 1 + 4 + 4)} = 3''\cdot 16 = 316 \text{ feet (about).}$$

and as the azimuth of the ray is 45°, this will produce a probable error in the length of the ray of $316 \times \sqrt{2}$ feet = 447 feet, and if the probable error of the length of the ray is not to exceed $\frac{1}{500}$, the ray must not be less than 500×447 feet long, or say forty miles.

(2) *Long Traverses.*—American experience shows that the longitudinal error of a long traverse under favourable conditions is not greater than $\frac{1}{3000}$. Assuming that this error in the unfavourable conditions of the Gold Coast may amount to $\frac{1}{1000}$, and that a traverse is run approximately north and south, how long should the traverse be in order to obtain a check from latitude observations? The probable error of an observation for latitude with a zenith telescope may be put down as 0″·1.

The probable error due to local attraction is about 2″·0.

Total probable error in difference of latitude

$= \sqrt{(\cdot 01 + \cdot 01 + 4 \cdot 0 + 4 \cdot 0)} = 2 \cdot 83$ or 288 feet.

If the latitudes are to be any check on the traverse, the probable error of their difference must not exceed that of the traverse, and the traverse must therefore not be shorter than 283,000 feet, or 54 miles.

Probable Errors of a Triangulation.—If the probable error of each angle of a triangle is p, then the probable error of the sum of the three angles is $p\sqrt{3}$.

If the triangular error is e, the probable error of an angle is $\frac{e}{\sqrt{3}}$.

In N triangles the probable error of an angle is $\cdot 67\sqrt{\frac{\Sigma e^2}{3N}}$, since the probable value of a triangular error is $\cdot 67\sqrt{\frac{\Sigma e^2}{N}}$.

Example.—The following were the triangular errors of a chain of secondary triangles. What is the probable error of an angle?

Triangular errors (e):—

$''$	e^2
2	4
5	25
3	9
4	16
6	36
1	1
4	16
3	9
2	4
6	36
4	16
0	0
5	25
7	49
	$\Sigma e^2 = 246$

The probable value of a triangular error $= \cdot 67\sqrt{\frac{246}{14}}$, and the probable error of an angle $= \cdot 67\sqrt{\frac{246}{42}} = 1'' \cdot 62$.

Peirce's Criterion.—In a set of theodolite angles between any two objects it is generally found that discrepancies occur in the readings even when the greatest care has been taken, and the first thing to be done is to see if any one or more of the readings should be rejected altogether. A practised observer can, after he has tabulated the angles, generally see if this is the case, but it is better for him to be regulated in his selection by some fixed mathematical law, instead of trusting merely to his judgment.

For this purpose *Peirce's Criterion* is excellent and simple in its application, by the use of the following table, p. 200, which is given in Chauvenet's 'Astronomy' and Wilson's 'Topographic Surveying.'

Let m = number of measures;

n = number of doubtful observations to be rejected (to be found by trial);

e = mean error of one observation in the set of m;

$v_1\ v_2\ v_3$ etc. = residuals of the observations or the difference of each value from the mean, and

x = ratio of required limit of error for the rejection of n observations, to the mean error e; so that $x\,e$ is the limiting error.

The value of x^2 for $n = 1$, and for various values of m is found from the table. All observations in which xe is greater than v are to be rejected.

EXAMPLE.

No.	Observed Angles.			v	v^2
	°	′	″	″	
1	42	20	18	1·2	1·4
2	42	20	25	5·8	33·6
3	42	20	10	9·2	84·6
4	42	20	20	0·8	0·6
5	42	20	23	3·8	14·4
	5)	101	36		134·6 = $\Sigma\ v^2$
Mean =	42	20	19·2		

In the above example v contains the differences between consecutive observations and the mean of the whole set, whilst v^2 is the square of

each of these differences. The sum of the squares of the differences $= \Sigma v^2 = 134 \cdot 6$. This number divided by the number of observations less 1, or

$$\frac{\Sigma v^2}{m - 1} = \frac{134 \cdot 6}{5 - 1} = 33 \cdot 6,$$

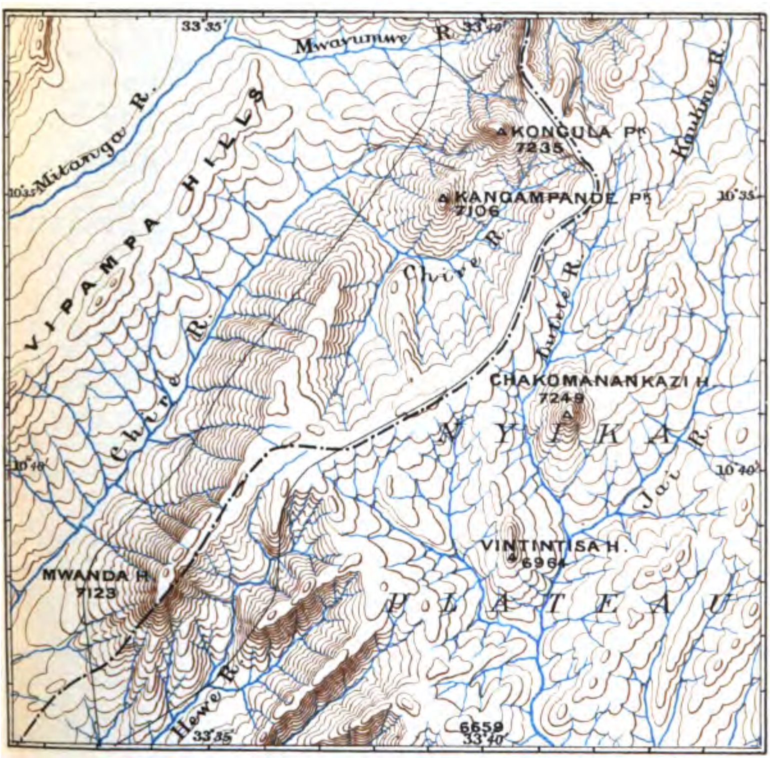
gives a quotient which, multiplied by the number from the table of constants for five observations in the table, gives $2 \cdot 278 \times 33 \cdot 6 = 76 \cdot 5$. Should any number in column v^2 exceed this product, the observation from which it is found must be rejected, and a new mean must be found for the remaining angles. In the present case No. 3 has to be rejected. Peirce's Criterion is also employed in determining the probable error and in rejecting doubtful observations in astronomic work.

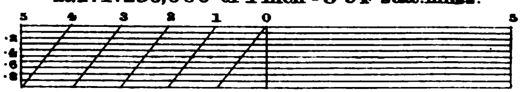
Peirce's Criterion.

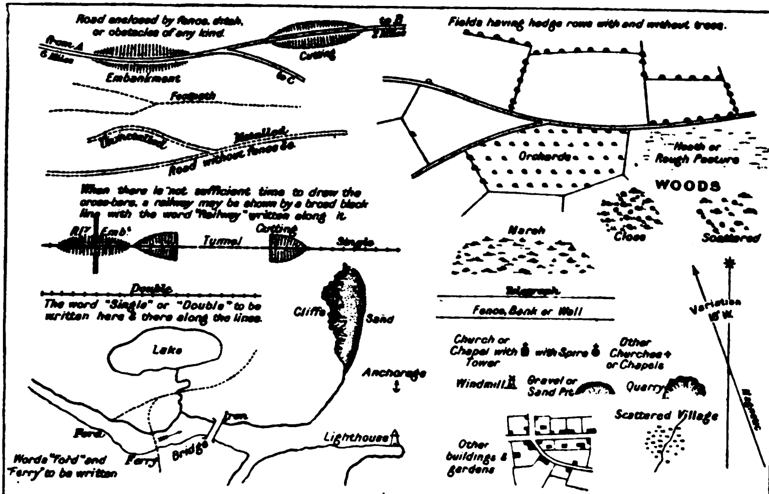
Values of x^2 for $n = 1$.

m	n: 1	2	3	4	5	6	7	8	9
3	1.480								
4	1.912	1.163							
5	2.278	1.439							
6	2.592	1.687	1.208						
7	2.866	1.910	1.409	1.045					
8	3.109	2.112	1.589	1.229					
9	3.327	2.295	1.753	1.388	1.091				
10	3.526	2.464	1.904	1.531	1.242				
11	3.707	2.621	2.045	1.662	1.373	1.122			
12	3.875	2.766	2.176	1.785	1.492	1.249	1.018		
13	4.029	2.902	2.299	1.901	1.604	1.362	1.145		
14	4.173	3.030	2.416	2.009	1.709	1.465	1.255	1.053	
15	4.309	3.151	2.526	2.111	1.807	1.561	1.354	1.163	
16	4.436	3.264	2.630	2.207	1.898	1.651	1.445	1.259	1.080
17	4.555	3.371	2.729	2.300	1.985	1.736	1.529	1.347	1.176
18	4.668	3.475	2.824	2.389	2.069	1.817	1.609	1.428	1.261
19	4.776	3.571	2.914	2.474	2.150	1.895	1.685	1.504	1.341
20	4.878	3.664	3.001	2.556	2.227	1.970	1.757	1.576	1.415
21	4.975	3.755	3.084	2.634	2.301	2.041	1.827	1.644	1.483
22	5.068	3.840	3.164	2.709	2.373	2.109	1.893	1.710	1.549
23	5.157	3.923	3.240	2.782	2.442	2.176	1.957	1.773	1.612
24	5.242	4.002	3.315	2.852	2.509	2.240	2.019	1.833	1.671
25	5.324	4.078	3.387	2.920	2.573	2.302	2.079	1.892	1.729
26	5.403	4.151	3.456	2.986	2.636	2.362	2.137	1.948	1.784
27	5.479	4.222	3.523	3.049	2.697	2.420	2.194	2.003	1.838
28	5.552	4.291	3.588	3.111	2.756	2.477	2.249	2.056	1.891
29	5.622	4.358	3.651	3.171	2.813	2.532	2.302	2.108	1.941
30	5.690	4.422	3.712	3.229	2.869	2.586	2.354	2.158	1.990
31	5.756	4.484	3.772	3.285	2.923	2.638	2.404	2.207	2.038
32	5.820	4.545	3.829	3.340	2.976	2.689	2.454	2.255	2.085
33	5.882	4.604	3.884	3.394	3.028	2.738	2.502	2.302	2.130
34	5.942	4.661	3.939	3.446	3.078	2.787	2.549	2.347	2.175
35	6.001	4.717	3.992	3.497	3.127	2.834	2.594	2.392	2.218
36	6.058	4.771	4.044	3.547	3.174	2.880	2.639	2.436	2.261
37	6.113	4.823	4.095	3.595	3.221	2.926	2.683	2.478	2.302
38	6.167	4.874	4.144	3.643	3.267	2.970	2.726	2.520	2.343
39	6.219	4.925	4.192	3.689	3.312	3.013	2.768	2.561	2.383
40	6.270	4.974	4.239	3.734	3.356	3.055	2.809	2.601	2.422
41	6.320	5.022	4.285	3.779	3.398	3.097	2.849	2.640	2.460
42	6.369	5.069	4.331	3.822	3.440	3.138	2.888	2.678	2.497
43	6.416	5.114	4.375	3.865	3.481	3.178	2.927	2.716	2.534
44	6.463	5.159	4.418	3.906	3.521	3.217	2.965	2.753	2.570
45	6.508	5.202	4.460	3.947	3.561	3.255	3.002	2.789	2.606
46	6.552	5.245	4.501	3.987	3.600	3.293	3.039	2.825	2.641
47	6.596	5.287	4.542	4.026	3.638	3.330	3.075	2.860	2.675
48	6.639	5.328	4.581	4.065	3.675	3.366	3.110	2.894	2.708
49	6.681	5.368	4.620	4.103	3.712	3.401	3.145	2.928	2.741
50	6.720	5.408	4.657	4.140	3.748	3.436	3.179	2.962	2.774
51	6.761	5.447	4.695	4.176	3.784	3.471	3.213	2.994	2.806
52	6.800	5.484	4.732	4.212	3.819	3.505	3.246	3.027	2.838
53	6.838	5.522	4.768	4.247	3.853	3.538	3.279	3.059	2.869
54	6.876	5.559	4.804	4.282	3.887	3.571	3.311	3.090	2.899
55	6.913	5.595	4.839	4.316	3.920	3.603	3.342	3.121	2.829
56	6.950	5.630	4.873	4.349	3.952	3.635	3.373	3.151	2.959
57	6.986	5.665	4.907	4.382	3.984	3.666	3.404	3.181	2.948
58	7.021	5.699	4.941	4.415	4.016	3.697	3.434	3.210	3.017
59	7.050	5.733	4.974	4.447	4.047	3.728	3.463	3.239	3.046
60	7.990	5.766	5.006	4.478	4.078	3.758	3.492	3.268	3.074

SPECIMEN OF TOPOGRAPHICAL MAP.



R.F. 1:250,000 or 1 inch = 3·94 stat. miles.

CONVENTIONAL SIGNS.



Towns and Villages (on small scales)

Railways existing

" under construction

Main Roads and Tracks

Other Routes

Heights in feet above sea level (to correspond with style of name)

Rivers

Wadis, Kors, Tugs

Permanent Wells, Springs, Pans, Dams W S P D (Blue)

Temporary " " " W S P D (Blue)

Doubtful Water ? (Blue)

EXAMPLES OF LETTERING.

COUNTRY

DISTRICT District

TRIBE Tribe

TOWN Town *Village*

SEA

LAKE Lake Lake

River River

Mountain Hill

Cape, *Cape*

Kazembe's, *Lupungus* *(Chiefs' names)*

RUINS, ANCIENT SITES

Explanatory matter. Dates &c.

7500. *1230* *Altitudes*

Scale 1:1,000,000 or 1 inch = 15·78 stat. miles

PART V.

ASTRONOMICAL OBSERVATIONS.

Definitions of Practical Astronomy.

The *Zenith* is the point vertically over the observer, and distant 90° from the rational horizon at every point.

The point opposite the zenith, or under the observer's feet, on the other side of the centre, is called the *Nadir*.

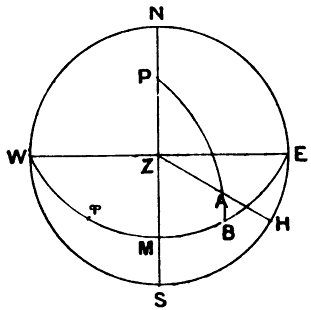


FIG. 76.

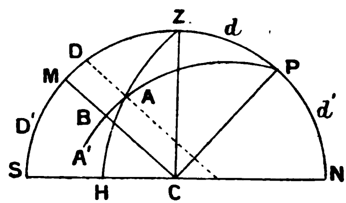


FIG. 77.

In Fig. 76, N W S E represents the *Rational Horizon;* N S, the *Meridian* of the observer; N, S, E, W, the north, south, east, and west points; Z, the zenith, which is seen directly over, or in one with the centre. This figure is drawn on the plane of the rational horizon, and shows the several circles as they would appear to an eye looking down vertically from a point at a great distance above the zenith.

Fig. 77 is drawn on the plane of the meridian, and shows the several circles of the upper or visible half of the sphere, as they would appear to the eye situated at a great distance due east of the sphere. In this figure the circle N W S E of Fig. 76, or the horizon, appears as a straight line, N S being seen edgewise; while the meridian, which in Fig. 76 is the straight line N S, appears here as the semicircle N P Z S. The E and W points are seen in one with the centre.

Of these two figures, that one would naturally be preferred which would best illustrate a proposed case.

P, the *Pole* of the heavens, is the point which remains fixed, whilst the rest of the celestial surface seen above the horizon appears to revolve.

The pole P is here represented as the North Pole; the other extremity of the axis round which the sphere appears to revolve is the South Pole, and takes the place of P when the figure is drawn for S. lat.

The circle E M W, 90° from the pole, is the *Celestial Equator.* The plane of the earth's equator being extended to the heavens marks on the sphere the celestial equator.

A *Celestial Meridian* is a circle passing through the poles of the heavens and the zenith; P Z S is the celestial meridian of the spectator. The plane of the terrestrial meridian extended to the heavens marks on the sphere the celestial meridian.

Circles of Altitude are circles passing through the zenith, and vertical at the place of the spectator. Thus Z A H is the circle of altitude passing through a star A. Such also are Z M S, Z P N.

The *Prime Vertical* is the vertical circle E Z W passing through the E. and W. points. In Fig. 77, E Z W does not appear, being in one with C Z, a radius joining the centre and zenith.

When the observer is on the equator, the celestial equator and prime vertical coincide.

Altitude is measured on a circle of altitude from the horizon; thus A H is the altitude of A.

The arc A H is the measure of the angle A C H, which would be formed at the centre by two straight lines, C H and C A. The altitude of a body M on the meridian is M S, which is the measure of the angle M C S.

Parallels of altitude are circles parallel to the horizon.

Zenith distance is the arc included between the zenith and the celestial body, or the angular distance of a body from the zenith of which that arc is the measure. The zenith distance is, therefore, the complement of the altitude to 90°, as Z A.

The altitude of a celestial body, as seen from the surface of the earth, is called the *apparent* altitude; as seen from the centre, the *true* altitude.

A ray of light, proceeding from the body, when not in the zenith, to the eye, in traversing the earth's atmosphere, which is heavier, or denser, as it is nearer the surface, is bent more and more as it approaches the earth, towards the perpendicular direction; and as the spectator sees any object, not always in its true direction, but in that direction in which the light from it finally enters his eye, a celestial body appears higher than its true place. Thus, the ray S A (Fig. 78), which proceeds from a star, is more and more bent towards the vertical line A Z as it approaches the surface, whereby the spectator sees the star in the direction A S′, and therefore higher than its true position.

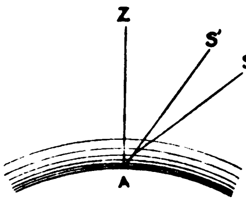


FIG. 78.

The ray A Z, which traverses the atmosphere perpendicularly, undergoes no refraction.

This alteration in the apparent place of a celestial body, caused by the atmosphere, is called the *Astronomical Refraction.*

The astronomical refraction is 0 at the zenith, and about 34′ at the horizon; hence a celestial body, when really on the horizon, appears elevated 34′ above it, and is seen on the horizon when really 34′ below it. From the same cause all the celestial bodies rise earlier and set later than they would were there no atmosphere.

The refraction varies with the density or weight of the air, being greater when the barometer is high, or the air cold, and less when the barometer is low, or the air warm. The *mean refraction*, or that in the average state of the atmosphere, is given in Table III., and corrections for different states of the air in Tables IV. and V.

Since refraction causes the object to appear too *high*, it is to be *subtracted* from the apparent altitude in reducing it to the true altitude.

Parallax in Altitude is the angular depression of a celestial body, in consequence of its being seen from the surface instead of the centre of the earth, as in Fig. 79.

The body S, which is vertical to the spectator (who always stands with his feet towards the centre) at B, in the line C S, appears at T, being seen in the direction of C S T; while to a spectator at A the same body appears below T at U, or in the direction A S U; the angle A S C, or T S U, which is equal to A S C, is the *parallax in altitude.* (Tables VI. and VII.)

The spectator at B sees S in the same line as if he were at the centre; that is, a body in the zenith has no parallax. To a spectator at D, to whom S appears in the horizon, the depression, or parallax, is greater than at any other point.

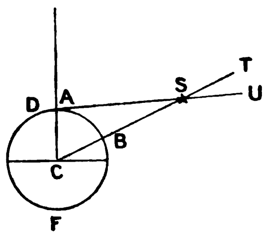


Fig. 79.

The parallax at the horizon is called the *Horizontal Parallax.*

Since parallax makes the object appear too *low*, it is to be *added* to the apparent altitude, in reducing it to the true altitude.

It is evident, by Fig. 79, that the farther off a celestial body is, the less parallax it will have; and the nearer, the more. The sun has about 9″ hor. par.: the moon has about 1°.

The parallax will obviously be less if the earth's radius is less. Now, owing to compression of the earth, the radius, or line from the centre to the surface, in any latitude, is less than at the equator; hence the moon's hor. par. in the 'Nautical Almanac,' which is the *equatorial* hor. par., is too great for any other latitude. The reduction is given in Table XVIII.

The *Semi-Diameter* of a celestial body is half the angle subtended by the diameter of the visible disc.

It is evident that the semi-diameter will be greater as the body is nearer, and smaller as it is farther off.

When the body S is in the zenith, it is nearer to the spectator by half the earth's diameter, C B, than when it is on the horizon; hence it appears larger when in the zenith. This increase of apparent dimensions

due to increase of altitude is sensible in the case of the moon only, and is called her augmentation. This is given in Table XIX.

The *Declination* of a celestial body is the portion of the meridian between the equator and the body; it is reckoned from the equator, and is either north or south. Thus A B, Fig. 77, p. 202, is the declin. of A, and is north.

Since the declination is measured on the celestial meridians, these are called also declination circles.

Parallels of Declination are circles parallel to the equator, as the dotted line through A, in Fig. 77, p. 202.

Thus declination is reckoned from the celestial equator as latitude on the surface of the earth is reckoned from the terrestrial equator; and as both these circles are in one and the same plane, declination and terrestrial latitude correspond: that is, a star in 28° N. decl. passes every day vertically over all places in 28° N. lat.

Polar Distance is the arc of the celestial meridian between a celestial body and the pole, or the angular distance of a body from the pole. When the lat. and decl. are of the *same* name, the pol. dist. is the complement of the decl. to 90°, because the distance from the pole to the equator is 90°; when the lat. and decl. are of *different* names, the pol. dist. is the *sum* of the decl. and 90°. Thus, the pol. dist. of A is P A; that of A′ in S. decl., Fig. 77, is P A′, which is the sum of 90° and A′ B.

The *Azimuth* of a celestial body is the angle at the zenith contained between the meridian of the place of the spectator and the circle of altitude passing through the body. It is usually reckoned to begin from that part of the meridian which is on the polar side of the zenith, that is, from the north in N. lat.; thus, the angle P Z A (Figs. 76–77) is the azimuth of A, but in the geodetic computations (pp. 108–116) it is reckoned from the south point round to the west.

When a body is on the prime vertical its Azimuth is 90°.

Since Refraction and Parallax take place vertically, they do not affect the azimuth of a body.

The *Amplitude* is the arc of the horizon between a celestial body at rising or setting and the E. or W. point, and is the complement of the azimuth; thus E H (Fig. 76) is the amplitude of a body rising at H. Amplitude is reckoned from the E. or W.; thus, if E H is 27°, the amplitude of H is E. 27° S.

The *Latitude*, or distance of the observer from the equator, is measured on the celestial sphere by the distance in arc of his zenith from the celestial equator; or Z M is the measure of the latitude, Figs. 76–77.

Suppose now D, a star of N. decl., on the meridian at D, then M D is its decl. and Z D its zenith distance; here Z M, the lat., is the *sum* of the decl. and zen. dist.

If D′ be a star of S. decl., Z M is the *diff.* of Z D′ and M D′.

If a star *d* be between Z and P, the lat. Z M is the difference of M *d* and Z *d*.

When the object is to the south of the observer, that is, when his zenith is to the north of the body, the zen. dist. is commonly called N.; when his zenith is to the south of the body the zen. dist. is called S. In Fig. 77, Z D and Z D′ are therefore called North; Z *d* is called South.

It appears, hence, that when the decl. and zen. dist. are of the *same* name, their *sum* is the latitude; when of *different* names, their *difference* is the latitude.

But when the star is below the pole, as at *d′*, the lat. Z M is the diff. of M *d′* and Z *d′*, and M *d′* is the sum of M P and P *d′*, or of 90°, and the compl. of the decl.

M Z being the lat., P Z is the colat., since P M is 90°. Also Z N being 90°, P N is the compl. of P Z, and therefore equal to M Z; or the elevation of the pole is equal to the lat. of the place.

The altitude of the uppermost point of the equator on the meridian, or M S, is equal to the *Colatitude*, because Z S is 90°. By noting this, and also that the equator passes through the E. and W. points, it is easy, in looking towards the heavens, to figure in the mind, roughly, the position of this circle. This is often useful.

In high latitudes, P in the figure (Fig. 77) falls near Z; in low latitudes, P falls near N. On the equator, Z and M coincide, the celestial equator there passing over the spectator's head.

In S. lat. the letters N and S in the figures are changed; also the direction of the celestial motions (which we in N. lat. consider from left to right) is there reversed, because in S. lat., in looking towards the equator, the E. is on the right hand.

Occultation is the disappearance or hiding of a celestial body by the

intervention of another. Thus the stars in the moon's path are occulted by her, and the satellites of a planet by the body of the planet.

It will be perceived that stars which are visible in the west soon after sunset disappear after some days in the solar light; and in like manner, that stars which are faintly seen in the east before sunrise become more distinct from day to day. Hence the sun, besides revolving daily with the fixed stars from east to west, has an apparent yearly motion amongst them in the contrary direction, or from west to east, completing the circuit of the heavens in the course of a year. This is really due to the earth's annual path in its orbit round the sun.

The path on which the sun appears to move, or the great circle which he seems to describe in the heavens, is called the ecliptic.

The ecliptic is divided into twelve signs, or portions of 30° each, called the *Signs of the Zodiac.*

Besides this perpetual motion from west to east, the sun is always changing his declination, which varies between 23° 28′ N. and 23° 28′ S. He crosses the equator twice in the year, namely, about the 20th of March in coming up to us in N. lat. from the southward, and again about the 23rd of September in going to the southward.

An *Hour-angle* is the angle at the pole contained between the meridian of the place and the celestial meridian passing through the body; thus, Z P A is the hour-angle of A (Fig. 77). An hour-angle is measured by the arc of the equator contained between the meridian of the place and that of the body; thus M B, Fig. 77, measures Z P A.

The hour-angle is thus measured on the celestial equator in the same way as longitude is measured on the terrestrial equator.

The *Right Ascension* of a celestial body is the arc of the equator included between the first point of *Aries* and the celestial meridian of the body; it is reckoned from west to east. Thus, if ♈ be the first point of *Aries*, Fig. 76, p. 202, the arc ♈ M B is the right ascension of the body A. The 360° of the celestial equator are divided into 24^h of R A.

The apparent revolution of the stars is perfectly regular, and is the only motion of the kind known.

One revolution of the earth round its axis, or, which is the same thing, the return of the same fixed star to the meridian after completing the circle, constitutes a *sidereal day;* this day consists of 23^h 56^m 4^s of common or mean time, as measured by clocks and watches. It is divided

into twenty-four hours, called sidereal hours, and these into sidereal minutes and seconds. Thus a sidereal day is about 10^s an hour shorter than a common or mean day; and the sidereal hours, minutes and seconds, in the same proportion.

The sidereal day being thus, in round numbers, 4^m shorter than the mean day, a star that passed the meridian last night at 9 p.m. will pass this evening at $8^h\ 56^m$, and so on, till after a few months it will pass at noon.

Sidereal Time begins (that is, a sidereal clock, regulated to sidereal time, shows $0^h\ 0^m\ 0^s$) when the first point of *Aries* is on the meridian, and is counted through twenty-four hours till the same point returns again; the hour-angle of this point is accordingly sidereal time.

The hour-angle of the first point of *Aries* is the *Right Ascension of the Meridian*, which is accordingly Sidereal Time. Difference of R A may, in like manner, be considered as a portion of sidereal time.

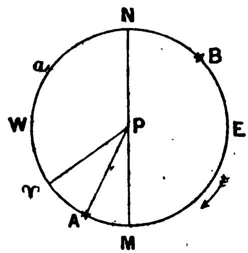


Fig. 80.

In Fig. 80 P is the pole, the circle N W M E the celestial equator, to which the measures of all hour-angles are referred. The bent arrow shows the direction of the apparent diurnal motion of the celestial bodies reckoned from east to west, supposing the spectator to face the south. M N is the observer's meridian.

A is any celestial body, as a star, which has passed the meridian at M, then A P M is the *hour-angle* of A, of which the arc A M is the measure.

(1) B is a star to the eastward of the meridian, which it has passed at N; its hour-angle, reckoned westwards, is measured by M W N B. We may, however, employ also B M, the measure of the hour-angle reckoned eastwards. Thus, instead of $14^h\ 11^m$ W. we may call it $9^h\ 49^m$ E.

(2) Let the first point of *Aries* be at ♈, having passed the meridian before the star A; then ♈ M is the *right ascension* of the meridian, that is, *Sidereal Time*. The R. A. of A is ♈ A; that of B is ♈ M B, reckoned always from west to east, or opposite to the diurnal motion; and ♈ N B is the supplement of the R. A. of B to twenty-four hours.

(8) The *sidereal time* ♈ M is the sum of the arcs ♈ A and A M, that is, of the hour-angle and R. A. of the star A. Again, ♈ M is the difference between the arcs *a* M and *a* ♈, that is, between the hour-angle of the star *a* and the supplement of its R. A. In the case of the star B, the sidereal time is the difference between its R. A. ♈ M B, and its hour-angle M B.

The hour-angle of the sun, reckoning always westward from the meridian, is *Apparent Time*. Thus, when the sun's meridian has passed over 48° of the celestial equator to the westward of the meridian of the place, it is said to be $3^h\ 12^m$ apparent time. Apparent time is the time shown by the sun-dial.

The interval between the sun's passing the meridian on one day and the next, or the *apparent solar day*, is not always of the same length, the difference being sometimes half a minute between one day and the next. Apparent time serves well enough in cases where this irregularity does not appear, or is of no importance; as for example at sea, where, from the continual change of longitude, the time must be obtained by observation, but where account of the time is to be kept by mechanism alone it must necessarily be divided into portions of invariable length.

The time for general use must, accordingly, unite the two advantages of being regulated by the sun and of being perfectly uniform. The mean or average day of twenty-four hours must therefore be an average taken of all the days in the year, that is, such a day as the sun would regulate if he moved uniformly in R. A. This average day is called the *Mean Solar Day*, and time thus regulated is called Mean Solar Time, or mean time, which is that shown by clocks and watches.

The sun being generally either behind or in advance of the position which he would have occupied if he had moved uniformly, mean time is in general either fast or slow, on apparent time. The correction for this irregularity, that is, the difference between the sun-dial and the mean solar clock, is called the Equation of Time. Mean time is, therefore, deduced from apparent time, by applying the equation of time. See the 'Nautical Almanac,' pp. I. and II. for each month.

The *Sidereal Time at Mean Noon* is the Right Ascension of the Meridian at the instant when the sun, if he moved uniformly, would be on it. It is therefore also called *Mean Sun's Right Ascension* at Mean Noon.

(1.) Let $\odot$ (Fig. 81) be the place of the sun, at about 4 p.m., *m* the place where he would be if he always moved uniformly ; then $\odot$ M is *apparent time*, *m* M is *mean time*, and *m* $\odot$ is the *equation of time*. The equation is here *additive* to app. time, as is the case from January to March, and from July to August.

(2.) Let ♈ be the first point of Aries ; then, while the sun and ♈ revolve, the sun appears to move contrary to the diurnal rotation, or is always *increasing* his R.A., or the arc ♈ N $\odot$, by nearly 1° a day. The complete revolution of ♈ constitutes a *sidereal day ;* that of $\odot$, an *apparent solar day ;* and that of *m*, a *mean solar day*.

After 24 sidereal hours the sun has still to describe about 1°, or one 360th part of the circle to complete it, the time necessary for which is about one 360th of 24 sidereal hours, or 4 sidereal minutes. Thus the solar day is longer than the sidereal day by about 4^m. The *mean solar day* being divided into 24 hours, the sidereal day is $23^h\ 56^m\ 4^s$ of such a day.

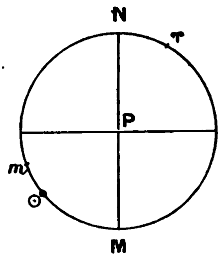


Fig. 81.

(3.) When *m* is on the meridian at M, the arc M *m* ♈, or the sun's mean R.A., is the *sidereal time at mean noon*. When *m* has arrived at *m* in the figure, this quantity has changed by an amount proportional to the mean time M *m*.

The $\odot$ moves sometimes more quickly, at others more slowly; the point *m* (which is merely an imaginary situation of $\odot$, deduced by calculation, from knowing the limits within which the irregularities of its motion are confined) moves equably. Hence *m* $\odot$, the difference of these two, changes unequally.

(4.) The Sidereal Time, or distance of the point ♈ from the meridian, is obtained from the hour-angle of any celestial body. By applying to the place of ♈ the sid. time at mean noon, we obtain the place of *m*, or mean time.

Thus mean time is found from the hour-angle of a star.

Since the sun *m* passes over 15° of the circle in one mean hour, he arrives at the meridian of a place 15° *west* of N M one hour *after* he has passed N M, that is, at one o'clock of the time at any place, or all places, of which N M is the meridian. In like manner he passes a

meridian 15° *east* of M one hour *before* he arrives at M, that is, when the time on M is 11 o'clock in the forenoon, or 23 hours after the noon of the day before.

Thus the beginning of the day, and therefore the hour or time of the day, at one place differs from that of another place by the difference of longitude of the places, the time at the easternmost of the two being in advance of, that is, greater than, the time at the other. Hence when the times proper to two places at the same instant are known, their diff. long. is determined, or the relative positions of their meridians.

The *Civil Day* is dated from midnight, and the twelve hours are computed twice over; the Astronomical Day is dated from noon, and runs through the twenty-four hours.

The *Greenwich Date* is the time at Greenwich corresponding to any given time elsewhere.

COMPUTATIONS OF ASTRONOMICAL OBSERVATIONS.

A traveller merely passing through a tract of country cannot hope to make more than a rough map of a belt extending a short distance on either side of his path.

Upon the estimation of the length of his daily march, and of its mean direction, his map will mainly depend.

The degree of accuracy of these two important factors will depend upon his experience, upon the trouble he takes to find means of ascertaining his speed, and upon his power of estimating the mean value of a course made up probably of an infinite number of windings and deviations.

When isolated or other well-marked hills exist, he may, however, on camping for the night, be able to get a bearing with his compass of an elevation at or near his point of departure in the morning, which will give a greatly improved value to the direction of his day's march.

It is, however, evident that after a few days, especially in densely-wooded country, his position may be very much in error, and hence the necessity, if he wishes his map to be in any degree trustworthy, of fixing his position from time to time by astronomical observations.

A list of instruments necessary for taking these observations will be

found on pp. 13–27, but to ensure the best results it is absolutely necessary that the surveyor should carry a good transit theodolite, several half-chronometer watches (three at least), and a barometer and thermometer. When it is impossible to carry a theodolite, the observations must be taken with a good sextant, but the results cannot be depended upon to the same degree of accuracy as those taken with a theodolite. For instance, latitudes from north and south stars, taken with a theodolite, can be relied upon to within two or three seconds or arc, but with the sextant a probable error of eight or ten seconds should be allowed. (For further remarks on the relative values of the instruments, see p. 34).

The astronomical observations are to obtain Latitude, Longitude (or difference of longitude) and Azimuth.

The Latitude observations, hereafter described, are comparatively simple, and, in the case of latitude by meridian altitude, depend solely on the altitude observed.

Longitude observations are, however, more complicated, and, *whatever* method is employed, with the exception of the moon culminating star method, which, owing to the unsatisfactory results obtained, is now excluded from these 'Hints,' all *require accurate local time.* This can be found by altitudes of the sun or stars at some distance from the meridian, noting the time by the watch, or by equal altitudes, and by these observations the error of the watch on local time is obtained.

By repeating the observation in the same spot after the lapse of a few days, the daily rate of the watch can be obtained; and, supposing the watch to be in good order, and well taken care of on the march, this rate will for some days afford a means of finding the difference of longitude between any two places when observations for time have been taken.

The precise method of doing this will be hereafter described.

Observations of Heavenly Bodies with a Transit Theodolite.—In taking observations with a transit theodolite the instrument should be carefully levelled, care taken to remove the effects of parallax (*see* p. 33), and the adjustments occasionally tested as shown on pp. 33–36. All observations must be taken in pairs, with the face of the vertical circle to the left and right, and both verniers or micrometers read. The

correction for level error (*see* p. 44) should be applied In most theodolites, observations taken with the face of the vertical circle to the left are altitudes, whilst those taken with the face of the vertical circle to the right are zenith distances, and must therefore be subtracted from 90° to convert them into altitudes. The only difference in computing the results between theodolite observations and sextant observations is that theodolite observations, being taken face right and face left, and corrected for level error, there is no index error, and as the altitudes are measured direct they are not divided by 2 as in the case of sextant observations when an artificial horizon is used.

A page from an observation book giving a complete set of observations taken with a theodolite for obtaining the azimuth of a star, and thence the true bearing of an object, is given on p. 256. The same form can be used for observations for circummeridian altitudes for latitude and for time, the only difference being that the part for horizontal angles is not required.

Observations of Heavenly Bodies with the Sextant.—Before any good results can be expected from sextant observations, the observer must be able to read the angles quickly and accurately; the only way to become proficient in doing this is by practising with the instrument, especially at night, when the angles have to be read by the light of a lantern.

From the presence of different sources of instrumental error, it is necessary, in order to ensure accurate results, that observations should be taken so as to eliminate them.

The precise methods will be described under the head of each observation, but the general principle is, that any altitudes for any purpose should be balanced by others taken in the opposite direction, as in the case of east and west stars, or A M and P M sights of the sun for time observations, or by observing bodies on the opposite sides of the zenith, as in meridian observations of stars for latitude.

Owing to the instrumental errors acting in different directions on the results, the mean of those results will be the true time, or latitude, as the case may be.

To observe the altitude of the sun, using an artificial horizon.—Fill the trough of the horizon with quicksilver, and put on the roof. Put down the suitable shades before the index and horizon glasses, set the index of

the sextant to zero (0°); then with the artificial horizon between yourself and the sun, retire, looking into the horizon, until you see the sun's reflected image in it; look through the telescope collar, or plain tube, and horizon glass of the sextant at the sun itself; unclamp the index, and move it forward. This will bring the reflected image down, follow it with the eye until it slightly overlaps that in the horizon; clamp the index, and screw the inverting telescope into the collar (no time should be lost in doing this, or the sun's image may pass out of the field); then with the tangent screw make the contact perfect. It is always better to bring the object down into the horizon without the telescope, for by so doing time is saved, and the unpractised observer is less likely to be mistaken as to which limb he is observing. The following rule will, however, prevent any such mistake:—In the forenoon, or when the sun is rising, if the lower limb is observed, the images are continually separating; if the upper limb is observed, they are continually overlapping; and the contrary in the afternoon, or when the sun is falling. When the telescope is fitted with a dark shade to screw on to the eye end, it should be used instead of the moveable shades, and it is important that the index error (*see* p. 50) should always be obtained with the shade on the telescope with which the final contacts are to be made. If a roofed artificial horizon is used, the sides should be plainly marked, and the roof should be reversed at each set of three altitudes, *except when equal altitudes are observed* to find the error of the watch; in which case the observations must be taken with the same side of the roof towards the observer. In placing the horizon on the ground it should have one of the glazed sides of the roof in a direct line with the sun, so that its sides cast no shadow. Any object seen in the mercury appears to be just as much below the horizontal plane as it really is above it; all angles, therefore, observed in an artificial horizon must be halved *after* the index correction has been applied.

The foregoing remarks apply equally to stellar observations, the only difference being that no dark shades are required, and of course there is no upper or lower limb to be considered.

The following is a list of the observations with which a traveller should make himself familiar, and of which particulars are given in these Hints. They are given in order of the relative degree of dependence to be placed upon their results.

For Latitude.—

	Probable error.
(1) Circummeridian altitudes of N. and S. stars (taking the mean result of the pair)	″ ″ 2 to 3
(2) Meridian altitude of N. and S. stars (taking mean result of at least two pairs)	3 to 4
(3) Altitudes of *Polaris*	5
(4) Circummeridian altitudes of one star only, either N. or S. of zenith	8
(5) Circummeridian altitudes of sun	10
(6) Meridian altitude of star	10
(7) Meridian altitude of sun	15
(8) Double altitudes of star or sun	30 to 40

With the instruments usually carried by the geographical surveyor, doubtless the best method of obtaining the latitude is by circummeridian altitudes of N. and S. stars, using the meridian alts. of each star to obtain the approximate latitudes, and a set of east and west stars to find the error of watch on L M T, both of which are required for the computation.

For Longitude.—

	Probable amount of error in 300 miles route.
(1) Triangulation	300 ft.
(2) Electric telegraph	300 ft.
(3) Latitude and azimuth traverse	¼ mile
(4) Chronometric difference, mean of five half-chron. watches and observing E. and W. stars	¼ mile
When the sun is observed E. and W. of meridian, or only one star, the results will be less reliable.	
(5) Absolute longitude by an occultation of a star (one observation)	½ to 1½ miles

For Azimuth.—

(1) East and west stars.

(2) Placing theodolite in meridian by equal altitudes.

(3) Sun east and west of meridian.

(4) *Polaris* and Circumpolar stars at elongation.

In the above lists it is supposed that a transit theodolite has been used; when the altitudes have been taken with sextant the order would remain the same, but the results would be less reliable.

There is not space in these 'Hints' to give the investigations of the

formulæ for the computation of the following examples, but they will, in most cases, be found in Mr. E. A. Reeves' 'Trigonometry,' which has been specially prepared for the Royal Geographical Society's course of instruction in Practical Astronomy and Surveying, and can be purchased at the Society's office.

To Compute the Local Mean Time of Star's Meridian Passage.

When the meridian altitude or circummeridian altitudes of a star are to be observed to obtain the latitude it is necessary to know at least approximately what time the star will be on the meridian, in order that proper time may be allowed to prepare for taking the observation. This is obtained with sufficient accuracy for the purpose by subtracting the Sidereal Time at G.M.N. (p. II. N.A.) from the Right Ascension of the star, adding twenty-four hours to the latter when necessary to effect the subtraction. To compute the local mean time of a star's meridian passage *accurately*, proceed as shown in the following example:—

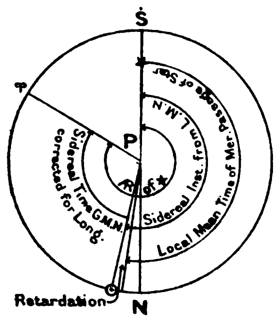


FIG. 82.

Required: the L.M.T. of Meridian Passage of *a Aquarii* for a place in long. 70° W. on July 12th, 1905.

	H.	M.	S.
Sidereal Time at G. M. N. (p. II. N. A.) (July 12th)	7	18	50·66
Acceleration for Longitude + if W. Long. / ,, ,, − if E. Long.		+	46·00
	7	19	36·66
Star's Right Ascension	22	0	56·48
Sidereal Interval from L. M. Noon	14	41	19·82
Retardation { 14 hours 2 M. 17·61 S.; 41 mins. 6·72; 20 secs. 0·05 }	−	2	24·38
Local Mean Time of Meridian Passage of *a* Aquarii (July 12th) ..	14	38	55·44

Latitude by Meridian Altitude of a Star.

July 12*th*, 1905.—At a place in approx. longitude 70° W., the meridian altitude of *a Aquarii* was observed with a sextant and artificial horizon to find the latitude.

Ther. 34°. Bar. 30 inches. Index error + 3′ 10″. Observer south of the star.

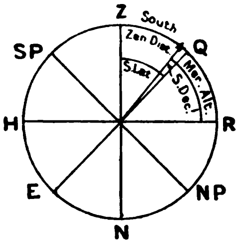


FIG. 83.

	°	′	″	
Alt. of ✱ in Artificial Horizon..	90	59	40	
Index error	+	3	10	
	2)91	2	50	
	45	31	25	
Refraction—Ther. 34°, Bar. 30 inches	−	00	59·5	
True Alt.	45	30	25·5	
	90	00	00	
Zenith Distance	44	29	34·5	S.
Declination	0	46	39·7	S.
Latitude..	45	16	14·2	S.

Latitude by Meridian Altitude of Sun (Sextant Observation).

February 3rd, 1905.—Approximate Longitude, 65° 30′ E. Thermometer, 47°. Barometer, 30·2 inches. Index error − 35″. Observer N. of ⨀.

Approx. Long., 65° 30′ E. = 4·37 h.

Var. of Decl. in one hour = 43″·91
×4·37

30737
13173
17564

191·8867 = 3′ 11″·9

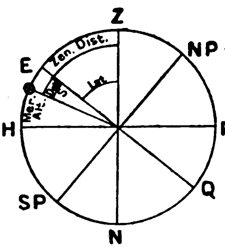


FIG. 84.

	°	′	″
Decl. of ⨀ (p. i. N.A.) Feb. 3rd	16	37	33·1 S.
Corr. for 4·37 h. E. Long.	+	3	11·9
Corrected Declination	16	40	45·0

	°	′	″
Mer. Alt. ⨀ in Art. Hor. ..	44	52	50
Index Error		−	35
	2)44	52	15
	22	26	7·5
Refr. {Ther., 47° / Bar., 30·2 inches} ..	−	2	23·1
	22	23	44·4
Parallax		+	8·2
	22	23	52·6
Semidiameter	−	16	15·0
True Mer. Altitude ..	22	7	37·6
	90	0	00·0
Zenith Distance	67	52	22·4N.
Declination	16	40	45·0S.
Latitude	51	11	37·4N.

When the *meridian altitudes of a star above and below the Pole* can be observed, half the sum of the corrected altitudes gives the latitude at once, without any computation. When the *Pole Star* can be observed, the latitude is very easily found by the rules and tables given in the 'Nautical Almanac.' An example of this computation is given on p. 224, together with the same observation worked another way. As a fairly correct approximation without any calculation at all, the corrected altitude of the Pole Star is the latitude, if the star is observed when β and ζ, or still better, when β and ϵ *Ursæ Minoris* appear to the eye to be in a line parallel with the horizon; a method which, as a rough observation, has the advantage of being independent of watch, tables, or 'Nautical Almanac.'

Latitude by Circummeridian Altitudes of a Star or Planet.

a Ceti. (Form for N. and S. stars.)

January 14th, 1905, Pilgrim's Path, Reigate. Approximate Lat. 51° 15′ 0″ N.; Long. in time 50 secs. W. Ther. 31°. Bar. 29·8 in. Observer N. of Star.

IF SEXTANT OBSERVATION.

	TIMES BY WATCH. H. M. S.		ALTITUDE IN ART. HOR. ° ′ ″
	)		)
Mean .. .. =			
Error of Watch on L.M.T. =		Index Err.	
L.M.T. .. .. =			2)
Approx. Long. in Time =			
Approx. G.M.T. (required when planet is observed) =		Obs. Alt.	

IF THEODOLITE OBSERVATION.

	TIMES. H.	M.	S.		LEVEL. E.	O.	ALTITUDES.	°	′	″	MEAN OF ALTITUDES. °	′	″
F. L.	7	18	11	..	11	11·5	C	42	27	0	42	27	10
							D	42	27	20			
F. R.	7	20	34	..	12	10·5	C	47	32	40	42	27	40
							D	47	32	0			
F. R.	7	22	24	..	12	10·5	C	47	31	40	42	28	50
							D	47	30	40			
F. L.	7	25	55	..	11·5	11	C	42	29	20	42	29	40
							D	42	30	0			

	H.	M.	S.
Sidereal Time at G. Mean Noon (P. ii. N.A.)	19	33	7·42
Acceleration for Longitude in Time, + if W.L., − if E.L.			·14
Reduced Sidereal Time .. .. .. =	19	33	7·56
Star's R.A. .. .. =	2	57	19·10
	7	24	11·54
Retardation { 7 hours = 1 m. 8·81 s.; 24 mins. = 3·93 s.; 11·5 secs. = 0·03 s. } =	−	1	12·77
Local Mean Time of Star's Transit	7	22	58·77
Error of Watch on L.M.T. (fast) ..	+	2	17·78
Time by Watch of Transit .. .. =	7	25	16·55

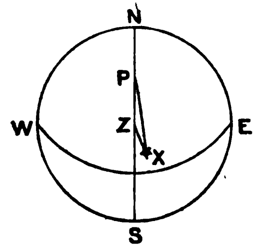


FIG. 85.

Reduction = P Z + Z X − P X. The value of which

F. L.	7	28	15	..	11·5	11	C 42 / D 42	28 / 29	40 / 20		42	29	0
F. R.	7	32	15	..	11	11·5	C 47 / D 47	33 / 32	10 / 10		42	27	20
	6)44	27	34		69	66				Mean	42	28	16·7
Mean .. .. =	7	24	35·66		66					Level Error ±		—	4·7
Error of Watch					12)3·0					Obs. Alt.	42	28	12·0
on L.M.T. (fast) −		2	17·78										
L.M.T. .. .. =	7	22	17·88		·25 × 18″·8 = 4″·7								
Approx. Long. in Time .. =													
G.M.T. ... .. =													

Time by Watch H. 7 M. 25 S. 16·55 at ✯'s Transit.

Watch Times.			Differences. Mean Time.*		Differences. Sidereal Time.		Nos. from Table VIII. 'Hints' (p. 283).	Meridian Zenith Distance (nearly).			
H.	M.	S.	M.	S.	M.	S.			°	′	″
7	18	11	7	5·55	7	6·71	99·3	Decl.	3	42	53·12
7	20	34	4	42·55	4	43·33	43·8	Lat.	51	15	0
7	22	24	2	52·55	2	51·02	16·3	M.Z.D.	47	32	6·88
7	25	55		38·45		38·56	·8	The Mer. ZD is equal to the sum of the Lat. and Decl. when they are contrary names, or their difference when they are the same name.			
7	28	15	2	58·45	2	58·94	17·4				
7	32	15	6	58·45	6	59·59	96·0				
							6)273·6				
							N = 45·6				

* The differences of Mean Time are found by taking the difference between Watch Times and the time of Transit or Meridian passage shown by Watch.

† If the object be a Planet, the Declination and Right Ascension must be corrected for the G.M.T. by the Daily Diff. (Mean Time N.A.), and allowance made for parallax and semidiameter.

is obtained from the formula : $\sin\frac{(PZ + ZX - PX)}{2} = \sin^2\frac{\text{hour angle}}{2} \sin PZ \sin PX \operatorname{cosec}\frac{PX + ZX - PZ)}{2}$ in the last term of which it is sufficient to use approximate quantities, since the Reduction must be very small.

	°	′	″		
Latitude ..	51	15	0	Log cos	9·796521
Declination .	3	42	53·12	Log cos	9·999087
M. Z. D. ..	47	32	6·8	Log cosec	0·132125
N.			45·6	Log	1·658965
Reduction ..			38″·6	= Log =	1·586798

	°	′	″
Observed Altitude	42	28	12
Refraction .. .. −		1	6·1
	42	27	5·9
Parallax (if a planet)		+	
Reduction		+	38·6
Meridian Altitude	42	27	44·5
	90	00	00
Meridian Zenith Distance	47	32	15·5 N.
Declination..	3	42	53·1 N.
Latitude	51	15	8·6 N.

NOTE.—The best results are obtainable when the altitudes are taken both E. and W. of the Meridian with Hour Angles not exceeding 15 minutes, and altitudes between 40° and 60°.

Latitude by Circummeridian Altitudes of the Sun.

February 17th, 1905. Approx. Lat. 30° 43′ 0″ N.; Approx. Long. 5° 20′ 0″ W. Ther. 62°. Bar. 30·1 in. Observer N. of ☉.

IF SEXTANT OBSERVATION.

TIMES BY WATCH. H. M. S.	ALT. ☉ ART. HOR. ° ′ ″
Mean	Mean

	H. M. S.
Mean of the Times by Watch ..	0 14 44·5
Error of Watch on L.A. Time (fast)	13 16
L.A. Time, corresponding to the mean of the Observations	0 1 28·5
Approx. Long. in Time W. ..	21 20
Approx. G. App. Time, corresponding to mean of Altitudes	0 22 48·5
	M. S.
Equation of Time (p. i. N.A.) Corr. by Hourly Diff. N.A. ..	
Corr. Eq. Time + or – to apparent Time (a)	
	° ′ ″
Decl. at G.A. Noon, p. i. N.A.	12 6 29·9
Corr. by Hourly Diff. N.A. for 22 min. 48·5 sec. ..	– 19·9
Decl. at mean of the Times	12 6 10·0 (b) S.

To find Time Watch will show at apparent Noon at place, when its error on G.M.T. is known.

	H. M. S.
Apparent Time of Noon	
Equation of Time (a)	
Local M.T. of Noon	
Longitude in Time	
Corresponding G.M.T.	
Error of Watch on G.M.T. ..	
Time Watch will show at apparent Noon at place	

Variation of Decl. in 1 hour ..	52·31″
Approximate G.A.T. expressed as decimal of an hour	·38
	41848
	15693
Correction =	19·8778

To find what Time the Watch will show at local Apparent Noon when error on G.M.T. is unknown.

	H. M. S.
Time of Noon	0 0 0
Error of Watch on Appt. Time at place + (fast)	0 13 16
Time Watch will show at Appt. Noon ..	= 0 13 16

	° ′ ″		
Latitude (Approx.)	30 43 0	log cos	9·934349
(b) Declination	12 6 10	log cos	9·990238
Mer. Z.D.	42 49 0	log cosec	0·167712
N.	36·5	log	1·562293
.. ..		log	1·654592

Reduction = 45″·14

IF THEODOLITE OBSERVATION.

	TIMES. H. M. S.		LEVEL. E. O.	ALTITUDES ☉ ° ′ ″	MEAN OF ALTITUDES. ° ′ ″
F. L.	0 9 12	..	9 10·5	C 46 53 15 / D 46 53 45	46 53 30
F. R.	0 11 20	..	10·5 9	C 43 4 0 / D 43 4 40	46 55 40
F. R.	0 13 5	..	11 8·5	C 43 3 10 / D 43 3 20	46 56 45

	° ′ ″
Mean Observed Altitude	46 54 6·7
Index (or level) error. Level error .. –	15·8
If taken in Art. Horizon, divide by .. 2	

		H.	M.	S.										
	F. L.	0	18	38	..	12·5	7	C	46	52	30	46	52	50
								D	46	53	10			
	F. R.	0	20	54	..	13	6·5	C	43	9	30	46	50	10
								D	43	10	10			
	6)	0	88	27		67·	5	48·5			6)	324	40	
Mean =		0	14	44·5		48·	5		Mn. obs. Alt.			46	54	6·66

$$12\,)\,19\cdot0$$
$$1\cdot58$$
$$\times\ 10''$$

Level Correction − 15·8

		°	′	″	
Corrected Refraction	−			53·1	
		46	52	57·8	
Semidiameter..	+		16	12·5	
		47	9	10·3	
Parallax	+			5·9	
		47	9	16·2	
Reduction	+			45·1	
Meridian Altitude		47	10	1·3	
		90	00	00·0	
Meridian Zenith Distance		42	49	58·7	N.
Declination (b)		12	6	10·0	S.
Latitude		30	43	48·7	N.

The difference between the Time the Watch shows at Noon, and each of the Times shown by the Watch when the Altitudes were observed, will be the Hour Angles.

Watch shows 0 H. 13 M. 16 S. at Apparent Noon.

Watch Times.	Hour Angles.*	Nos. Table VIII. 'Hints.'	☉'s Meridian Zenith Distance (nearly).		
H. M. S.	M. S.	″		°	′
0 9 12	4 4	32·5	Decl. at Appar.		
0 11 20	1 56	7·3	Noon at place	12	6 S.
0 13 5	0 11	0·1	Lat. (Approx.) ..	30	43 N.
0 15 18	2 2	8·1			
0 18 38	5 22	56·5	Mer. Z.D.	42	49
0 20 54	7 38	114·4			
		6)218·9	N.B.—The Mer. Z.D. is equal to the sum of the Lat. and Decl. when they are contrary names; or their difference when of the same name.		
	Mean ..	36·5 = N.			

* The best results are obtained when the Altitudes are taken both East and West of the Meridian, with the Hour Angles not exceeding 15 minutes.

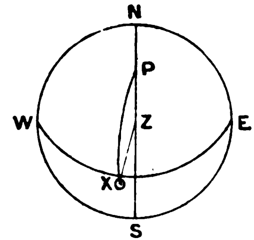


FIG. 86.

Reduction = P Z + Z X − P X. The value of which is obtained from the formula: $\sin\frac{(PZ + ZX - PX)}{2} = \sin^2\frac{\text{hour angle}}{2}\sin PZ \sin PX \operatorname{cosec}\frac{(PX + ZX - PZ)}{2}$ in the last term of which it is sufficient to use approximate quantities, since the Reduction must be very small.

† The error of Watch on apparent time at place can be obtained by a separate set of Altitudes of the sun at an Hour Angle of about 3 hours, or better still, by sets of Altitudes East and West of the Meridian. When the error of Watch on L.M.T. is known its error on apparent Time can be obtained by applying the Equation of Time.

Latitude by Altitudes of "Polaris."

January 21st, 1905, Redhill Common.—Approximate longitude, 45 secs. W. Barometer, 29·9 inches. Thermometer, 30°. L.M.T. Chronometer:—No. 27; Error, 2 min. 24·2 secs. fast; Rate (losing daily), 2 secs.

ELEMENTS.

Omitted if S.T. Chron. is used.		H.	M.	S.
	G.S.T. of G.M.N. (p. ii. N.A.) =	20	0	43·3
	Corr. for Long. at 9·86 sec. per hour (−E. + W.) ± =		+	·1
	∴ L.S.T. of L.M.N. .. .. =	20	0	43·4

		H.	M.	S.
	From Angle Book.			
	Mean of Observed Times .. =	5	45	7·3
	Chron. Corr. on L.M.T. .. .. ± =	−	2	24·2
	(Slow + Fast −)			
This is omitted if S.T. Chron. is used.	L.M.T. of Observation .. =	5	42	43·1
	S.T. Equivalents (N.A.) Hours 5 .. =	5	0	49·3
	Mins. 42 .. =		42	6·9
	Secs. 43·1 .. =			43·1
	∴ Sid. Int. from L.M.N. =	5	43	39·3
	L.S.T. of L.M.N. (see above) =	20	0	43·4
	*∴ L.S.T. of Observation .. .. =	1	44	22·7
		(−24 h.)		

REFRACTION.

	′	″
Refraction due to Obsd. Mean Alt. (Angle Book) .. .. .. =	0	44·9
Correction for Bar., 29·9 in. − =		0·2
Correction for Ther., 30° .. + =		2·1
Refraction corrected .. .. =	0	46·8

TRUE ALTITUDE (h)

	°	′	″
Observed Mean. Alt. (Angle Book) =	52	26	11·2
Correction Refraction .. .. =		−	46·8
∴ True Altitude (h) .. .. =	52	25	24·4

COMPUTATION BY TABLES IN NAUTICAL ALMANAC.

	°	′	″
True Altitude (h) (see above) .. =	52	25	24·4
Subtract .. .. =	0	1	0
Reduced Altitude .. .. .. =	52	24	24·4
With argt. L.S.T.* 1h. 44m. 23s. 1st Corr. −	1	11	44·6
∴ Approximate Latitude .. .. =	51	12	39·8
With argt. L.S.T.* and True Alt. 2nd Corr. =	+ 0		0·5
With argt. L.S.T.* and date 3rd Corr. =	+ 1		15·1
Latitude N. .. .. =	51	13	55·4

COMPUTATION BY FORMULA:—

$$\phi = h - p \cos t + \frac{p^2}{2} \sin^2 t \sin 1'' \tan h.$$

This computation gives more accurate results than those obtained by use of N.A. tables.

POLAR DISTANCE (p).

	°	′	″
Dec. (δ) .. .. =	88	48	16·19
	90	0	0·00
∴ p (or $90° - \delta$) .. .. .. =	1	11	43·81
∴ p (in seconds) .. .. .. =			4303·81″

HOUR ANGLE (t).

	H.	M.	S.
*L.S.T. of Observation .. .. =	1	44	22·70
R.A. of Star .. .. .. =	1	24	59·59
∴ t in time (S.T. − R.A.) ± .. = +	0	19	23·11
If t is negative subtract from 24 h.			

	°	′	″
∴ t in arc .. .. =	4	50	46·6

Log p (p in seconds) .. .. =	3·633853
Log cos t .. .. =	9·998445
Log 1st Corr. .. .. =	3·632298
1st Corr. (in seconds) .. .. =	4288·4″
Log p .. .. =	3·633853
Log sin t .. .. =	8·926768
Log p sin t .. .. =	2·560621
Log $p^2 \sin^2 t = 2 \times$ (Log p sin t) =	5·121242
Log tan h .. .. =	0·113818
Log sin 1″† .. .. =	$\overline{6}$·685575
Ar. comp. Log 2‡ .. .. .. =	$\overline{1}$·698970
Log 2nd Corr. .. .. .. =	$\overline{1}$·619605
2nd Corr. (in seconds) .. .. = +	0·42″

	°	′	″
True altitude .. .. .. = +	52	25	24·4
1st Corr. (opposite sign to cos t) = −	1	11	28·4
(If t is in 2nd or 3rd Quadrant cos t is −.)			
	51	13	56·0
2nd Corr. (always added) .. =			0·42
Latitude N. .. .. .. =	51	13	56·42

† log sin 1″ = $\overline{6}$·6855749.
‡ Ar. comp. Log 2 = $\overline{1}$·6989700.

Latitude by Double Altitudes of Star or Sun.

The method of obtaining the latitude by "double altitudes," as it is called, consists of observing two sets of altitudes of the same object with a considerable interval of time between them, or simultaneous sets of altitudes of different stars. The former is more satisfactory as a rule, and an example of this method is given here, worked out by Ivory's formula, which is the shortest, and is explained in 'Reeves' Trigonometry' (pp. 60, 61). The following is a brief explanation of the various "arcs," etc., used in the computation :—

Let A and B (Fig. 87) be the places of a heavenly body at the two

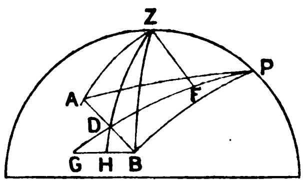


FIG. 87.

observations; P A, P B, the polar distances; Z A, Z B the zenith distances; A P B the polar angle or interval. P D is drawn perpendicular to A B, and divides A P B into two equal parts; Z F is perpendicular to P D.

Then Arc 1 is A D; Arc 2 is Z F; Arc 3 is P D. As P D is usually greater than A D, from which it is determined, if a small error occurs in A D, P D will be in error still more. Arc 4 is D F; Arc 5 is P F. P F here is P D − D F; but when the polar distance is much less than P Z, F may fall beyond D on P D produced, and then P F = P D + D F. The co-lat. P Z is then found from P F and Z F.

Although somewhat more lengthy, a more accurate result may at times be obtained by computing by the more straightforward methods of spherical trigonometry.

Taking the case given above :—

Let Z A and Z B be the two zenith distances of the heavenly body, P A and P B the polar distances, which in the case of a star will be

equal, and the angle A P B the interval of time between the observations. Then, in triangle P A B,

$$\cos AB = \frac{\cos PA}{\cos \theta} \cdot \cos (PB - \theta) \quad .. \quad .. \quad .. \quad (1)$$

where $\tan \theta = \tan PA \cos APB$

$$\sin PAB = \sin APB \cdot \sin PB \cdot \operatorname{cosec} AB \quad .. \quad .. \quad (2)$$

Next in triangle Z A B, of which the three sides are now given, the two zenith distances and the side A B found above, the latter being common to both triangles P A B and Z A B,

$$\sin^2 \frac{ZAB}{2} = \frac{\sin \frac{ZB + AB - ZA}{2} \cdot \sin \frac{ZB - AB + ZA}{2}}{\sin ZA \cdot \sin AB} \quad (3)$$

$$ZAB - PAB = ZAP \quad .. \quad .. \quad .. \quad (4)$$

Then in angle A Z P with the angle Z A P found above (4), and the two sides Z A and P A (zenith distance and polar distance) find the co-latitude P Z as follows:—

$$\cos PZ \text{ (the co-latitude)} = \frac{\cos AZ}{\cos \theta} \cdot \cos (AP - \theta) \quad .. \quad (5)$$

where $\tan \theta = \tan AZ \cdot \cos ZAP$.

The double altitude method *should only be used when it is impossible to obtain the latitude by any other means*, and it is quite unreliable when the latitude and declination are nearly the same; in fact, there should always be a considerable change in azimuth of the star or sun corresponding to the change in hour angle.

Latitude by Double Altitudes of Sun.

February 3rd, 1905.—Thermometer, 47°. Barometer, 30·2 inches.

		H.	M.	S.
Time by Watch of 2nd Alt. ☉ (+12h.)		15	6	29·25
Time by Watch of 1st Altitude ☉		10	55	43·8
	2)	4	10	45·45
½ Interval	=	2	5	22·72
Time of 1st Observation	+	10	55	43·8
Middle Time at Place	=	1	1	6·52
Approx. Error of Watch on G.M.T.	−		2	56·16
Middle Time at Greenwich ..			58	10·36

		°	′	″
☉'s Declination, Feb. 3rd, p. ii. N.A.		16	37	43·3
Correction by Hourly Difference ..				42·5
Corrected Declination	=	16	37	0·8

		°	′	″
1st Altitude in Artificial Horizon ..	=	39	8	10
Index Error	−			35
	2)	39	7	35
		19	33	47·5
Refraction .. = − 2 45·4; Semidiameter .. = + 16 14·96; Parallax .. = + 8·2	= +		13	37·76
1st True Altitude	=	19	47	25·26
2nd True Altitude	=	12	46	39·61
Sum of Altitudes	2)	32	34	4·87
½ Sum of Altitudes	=	16	17	2·43

		°	′	″
2nd Alt. in Artificial Horizon ..	=	26	14	25
Index Error	−			35
	2)	26	13	50
		13	6	55
Refraction .. = − 4 9·03; Semidiameter .. = − 16 14·96; Parallax .. = + 8·6	= −		20	15·39
2nd True Altitude	=	12	46	39·61
1st True Altitude	=	19	47	25·26
Difference of Altitudes	2)	7	0	45·65
½ Difference of Altitudes	=	3	30	22·82

½ Interval .. (H. M. S.) 2 5 22·72	Log sin .. 9·716158				
Declination = 16° 37′ 0″·8	Log cosin 9·981474	.. ..		Log sin ..	9·456321
Arc 1 = 29 53 53·8	Log sin = 9·697632	.. ..		Log sec ..	10·062024
Ar. Co. Log of Sin of Arc 1	·302368	Arc 3*	.. 109 15 39·5	Log cos ..	9·518345
				Rep. log Sec Arc 1	10·062024
½ Sum Alts. = 16° 17′ 2″·43	Log cos .. 9·982219	.. ..		Log sin ..	9·447776
½ Diff. Alts. = 3 30 22·82	Log sin .. 8·786460	.. ..		Log cos ..	9·999186
Arc 2 .. = 6 45 49	Log sin .. 9·071047	.. ..		Arc 2 Log sec ..	10·003033
		Arc 4 ..	.. 71 1 42	Log cos =	9·512019
		Arc 5† ..	.. 38 13 57·5	Log sec ..	10·104851
				Log sec Arc 2 ..	10·003033
		Latitude	= 51° 15′ 52″ N. =	Log cosec =	10·107884

* When Latitude and Declination are contrary names the supplement of the Cosine is Arc 3.

† In Tropical Latitudes, when the Latitude and Declination are the same name, and the Latitude is less than the Declination, the sum of Arcs 3 and 4 will be Arc 5, otherwise their Difference is Arc 5.

Observations for Time and Longitude.

Astronomical observations for longitude are of two kinds. (1) Observations which have for their object to find the difference of time and thence the difference of longitude between the station of the observer and that of a place whose longitude is known, or if not, assumed, and taken as the starting point for all the others.

(2) Observations to find the longitude directly, by the determination of Greenwich time astronomically, without the aid of a chronometer or watch showing Greenwich time, or, as it is termed, absolutely.

The first requires, when the time elapsed since the rate of the chronometer was last ascertained is great, a good and carefully-guarded timekeeper, and is known by the name of "meridian distance," or measuring the difference between the meridian of the place and that of the place where the chronometer was last rated, whose longitude is known. This method, when applicable, is by far the best, but in travelling requires that a continuous chain of observations should be taken from the time of leaving a place whose position is known; and as a watch, carried either by a pedestrian, or on horseback, rarely keeps an equable rate, the points where halts must be made for rating should not be more than five or six days apart.

The second method depends, in its various forms, almost entirely upon the rapidity of the moon's motion in the heavens, and, while it gives the longitude without reference to any previous observation, the result is always more or less rough, unless a great many observations are made on different nights, when the mean may approximate to the truth.

In any of these observations, with the exception of moon culminating stars, the true time at the place is required, and the method of finding this will first be described.

Whenever possible the difference of longitude between places should be obtained by triangulation or electric telegraph. The Latitude and Azimuth method is described on p. 117.

To find Error of Watch by Absolute Altitudes.

In finding local time by this observation it is not necessary that the longitude of the place should be known with any great degree of accuracy, as the Greenwich date, obtained by the longitude in time, is only used for correcting the elements taken from the 'Nautical Almanac,' and a considerable error in longitude would not produce any serious error in the Declination or Equation of Time. The body

should be observed as far from the meridian as possible, because, when nearly E. or W., errors, both of latitude and observation, produce the least effects on the hour angle. As a general rule, this observation should not be taken unless the sun or star is changing its altitude by *at least* 6′ in 1 m. of time. The readings of the barometer and thermometer should be noted.

The formula for finding local time, and thence error of watch and differences of longitude here and in the sun example is

$$\sin^2 \frac{A}{2} = \frac{\sin \frac{(a+b-c)}{2} \cdot \sin \frac{(a-b+c)}{2}}{\sin b \cdot \sin c},$$

where A is the hour angle; a, 90° − alt.; b, 90° − lat., and c the polar distance from the elevated pole. It is investigated in Reeves' 'Trigonometry,' pp. 48 and 62. This is convenient for travellers as special tables are given in Raper's 'Navigation' and other works of the values of $\sin^2 \frac{A}{2}$ in time, so that the work is much shortened, but when such a table is not available the hour angle can readily be found from the same formula by the rule given on the form.

The spherical triangle from which the hour angle is found is sometimes solved by the formula (investigated on p. 48 of Reeves' 'Trigonometry'):—

$$\tan \frac{A}{2} = \sqrt{\frac{\sin (a-b) \sin (s-c)}{\sin s \quad \sin (s-a)}}$$

An adaptation of this formula is that employed in the forms of the R.E. Survey School, which is stated as

$$\tan \frac{t}{2} = \sqrt{\cos s \quad \sin (s-h) \quad \operatorname{cosec} (s-\phi) \quad \sec (s-p)}$$

where t is the hour angle, h the altitude, p the polar distance from the elevated pole, ϕ the latitude, and

$$s = \frac{h + \phi + p}{2}.$$

The form for computing the hour angle by this formula is that given in the first form for finding local mean time by the altitudes of the sun (p. 232).

There is no difference in the other parts of the computation. The local mean time accepted should be the result of at least a pair of observations, one set being taken of a star E., and another W. of the meridian. The hour angle should never be less than 2½ hours, and the altitude not under 30°. When the sun is observed for time A.M. and P.M. sets should be taken, and the mean result accepted.

Local Mean Time from Altitude of a Star.

a Andromedæ (West star). (Form for E. and W. stars.)

January 14th, 1905, Pilgrim's Path, Reigate. Lat. 51° 15′ 18·6″ N. Approx. Long. in Time 50 sec. W. Ther. 31°. Bar. 29·8 in. Value of 1 division of level scale 19·2″.

	Times. H. M. S.	Level. E.	Level. O.	Altitudes.	° ′ ″	Mean of Altitudes. ° ′ ″
F. L.	7 42 38	12	10·5	C	47 58 30	47 57 50
				D	47 57 10	
F. R.	7 45 40	12	10·5	C	42 33 10	47 26 0
				D	42 34 50	
F. R.	7 47 45	12·5	10	C	42 52 20	47 6 45
				D	42 54 10	
F. L.	7 50 16	11·5	10·5	C	46 48 40	46 47 50
				D	46 47 0	
F. L.	7 52 26	12	10	C	46 29 0	46 28 5
				D	46 27 10	
F. R.	7 54 45	12·5	10	C	43 56 20	46 2 30
				D	43 58 40	
	6) 46 53 30	72·5	61·5			6) 281 49 00
Mean =	7 48 55	61·5			Mean Alt.	46 58 10
L.M.T. (found below) =	7 40 37·29	12) 11·0			Level corr.	— 17·6
		·917				46 57 52·4
Error of Watch on L.M.T. .. =	2 17·71	× 19·2″			Refraction —	56·5
	Level corr. —	17·606			‡ True Alt.	46 56 55·9

	H. M. S.
✱'s R.A. (N.A.)	0 3 28·12

	° ′ ″	
✱'s Declination (N.A.)	28 34 2·31	N.
	90 00 00	
✱'s Polar Distance	61 25 57·69	

	° ′ ″		
✱'s True Altitude ..	46 56 55·9		
Latitude	51 15 18·6	log sec	10·203528

Polar Distance ..	61	25	57·7	log cosec	10·056379
	2) 159	38	12·2		
Half Sum	79	49	6·1	log cosin	9·247406
Half Sum − Altitude	32	52	10·2	log sin	9·734582
				Log sin sq. of ½ hour =	9·241895 (a)

	H.	M.	S.	
✲'s Hour ∠	3	17	33·36	(a)
✲'s R.A.		3	28·12	
Sid. Time of Obs. or R.A. of Meridian ..	3	21	1·48 *	
L.S.T. of L.M.N.	19	33	7·56	(b)
Sidereal Interval from L.M.N.	7	47	53·92	
Retardation for Sidereal Interval (Table XVII.) or M.T. Equivalents (N.A. Table)	−	1	16·66	
† L.M.T.	7	46	37·26	

* When a chronometer rated to show Sidereal Time is carried, its error on L.S.T. is the difference between the mean of the times shown by the chronometer and the Sidereal Time of Observation or R.A. of the Meridian.

† When the G.M.T. is known, the difference between L.M.T. and the G.M.T. will be Longitude in Time.

‡ When a Planet is observed the altitude must be corrected for parallax and semidameter.

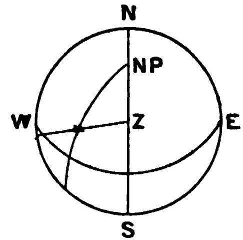


FIG. 88.

When no log sin sqr. table is available the hour angle can be found as follows: Take the sum of the four logs, as above, and divide it by 2: the result is the log sin of half the hour angle in degrees; from the table of log sin take out the arc corresponding thereto and multiply it by 2; convert the arc into time, and the result will be the hour angle.

		H.	M.	S.
G.S.T. of G.M.N. (p. ii. N.A.)	=	19	33	7·42
Accel. for Long. in Time − if E., + if W. ..			+	·14
L.S.T. of L.M.N. (b)	=	19	33	7·56

N.B.—When the Star is West of the Meridian, add the hour ∠ to the Star's R.A.; when to the East, subtract the Star's hour ∠ from its R.A. (increased, if necessary, by 24 hours); the result is the R.A. of the Meridian; from the R.A. of the Meridian (increased, if necessary, by 24 hours), subtract the L.S.T. of L.M.N. and the remainder, further diminished by Retardation or converted into M.T. by table of M.T. Equivalents (N.A.), will be M.T. at place, or L.M.T.

The example on p. 234 is convenient when a Mean Time Watch or Chronometer is carried, but the following Form, taken from the 'Text Book Topographical Surveying,' is applicable either for a Mean Time or Sidereal Time Chronometer :—

Local Mean Time by Altitudes of the Sun.

Those parts in *italics* are only necessary when the Chronometer keeps Sidereal Time.

Place, . Astronomical Date . Page in Angle Book, . Latitude,
N. or S., . Approximate Longitude, E. or W., . L.M.T. or S.T., Chron. No. .
Approximate Chron. Corr. on L.S.T. or L.M.T., . Ther. . Bar. .

ELEMENTS.

G.S.T. of G.M.N. (p. ii. N.A.) .. .. .. =
Corr. for Long. at 9·86s. per hour (− E. + W.) .. .. =

* *L.S.T. of L.M.N.* .. =

POLAR DISTANCE.

This is reckoned from the *Elevated Pole* $p = 90 \pm \delta$.

For Dec. (δ) at time of observation (see below).

	°	′	″
Dec. (δ). N. or S. .. =			
	90	0	0

∴ Polar Dist. (p) .. =

If the Lat. (ϕ) and Dec. (δ) are of the same name, δ is *subtracted* from, but if of different names, *added* to 90°.

FROM ANGLE BOOK : H. M. S.

† Mean of Observed Times .. .. ..
Approx. Chron. Corr. (slow + fast −) .. ±

L.S.T. of Obs. (Approx.) .. .. ..
* *L.S.T. of L.M.N.* ..

Sid. Int. from L.M.N.

M.T. Equivalents {*h.* *m.* *s.*}

L.M.T. of Obs. (Approx.) .. .. ..
Long. W. (+) or E. (−) ±

G.M.T. of Mean of Observed Times ..

‡ Interval in hours from G.M.N.

FORMULA AND COMPUTATION.

$$\tan\frac{t}{2} = \sqrt{\cos s \sin (s-h) \operatorname{cosec} (s-\phi) \sec (s-p)}$$

where $s = \dfrac{h+\phi+p}{2}$

The Lat. (ϕ) is *always* positive and p is reckoned from the *Elevated Pole.*

FROM ANGLE BOOK.

		° ′ ″
Obsd. Mean Alt.	=	
Refraction	= −	
Semi-diam.	= ±	
Parallax	= +	
True Alt. (h)	=	
Latitude (ϕ)	=	
Polar Dist. (p)	=	
	2)	

s	=		log cos
$s-h$	=		log sin
$s-\phi$	=		log cosec
$s-p$	=		log sec
		2)	

$\therefore \text{Log} \tan\frac{t}{2} =$

DECLINATION.

Dec (δ).

	° ′ ″
At Greenwich Mean Noon, N. or S.	
Hourly Var. (p. i. N.A.) × Int. in hours from G.M.N.	±
At Mean of Obsd. Times, N. or S.	

EQUATION OF TIME.

		M. S.	
(p. ii. N.A.)	±		(p. ii. N.A.)
	±		
	±		

REFRACTION.

	″
Refraction due to Alt. ..	
Correction for Bar. .. .. ±	
Correction for Ther. .. ±	
Refraction	

PARALLAX.

	′ ″
Hor. Par. (N.A.)	
×	
Cos h	
Parallax in Alt. ..	

	° ′ ″
$\therefore \frac{t}{2} =$	
t in arc =	

	H. M. S.
t in time ± =	
If before Noon subtract from	24 0 0
L.A.T. of Observation .. .. =	
Equation of Time .. .. ± =	
L.M.T. of Observation .. .. .. =	
Not req. with M.T. Chron.: *Sidereal Equivalents* .. .. { *h.* *m.* *s.*	
∴ Sidereal Int. from L.M.N. .. =	
* *But L.S.T. of L.M.N.* .. .. .. =	
∴ L.S.T. of Observation .. =	
† Chron. Time of Observation .. .. =	

	M. S.
Chron. slow or fast ± on L.S.T. or L.M.T. =	

Local Mean Time from Altitude of the Sun (Sextant Observation).

March 10th, 1905. Latitude 51° 14′ 55·5″ N. Approx. Long. in Time 50 sec. W. Ther. 49°. Bar. 29·2 inches.

	TIME BY WATCH. H. M. S.
	10 16 35
	10 23 31
	10 26 45
	10 31 20
4)	98 11
Mean	10 24 32·75
Approximate Error of Watch on L.M.T. (fast)	− 16 0
Approximate L.M.T...	10 8 32·75
Approximate W. Long. in Time ..	+ 50
Approximate G.M.T...	10 9 22·75
	12 0 0·00
Interval from G.M. Noon	1 50 37·25

	° ′ ″	
True Altitude	28 38 21·0	
Latitude ..	51 14 55·5	Log sec = 10·203466
Polar Distance	94 16 59·0	Log cosec = 10·001215
	2)174 10 15·5	
Half Sum ..	87 5 7·7	Log cosin = 8·706254
Diff. between Half Sum and True Alt. ..	58 26 46·7	Log sin = 9·930517
	†Log sin square..	8·841452

	H. M. S.
Hour ∠	2 2 12·4
	*24 00 00·0
Local Apparent Time, March 9th ..	21 57 47·60
Eq. of Time .. .. ±	+ 10 34·15
L.M.T.	22 8 21·,
Mean of Watch Times	22 24 32·75
Error of Watch on L.M.T. (fast) ..	0 16 11·0

	ALT. OF ☉ IN ART. HOR. ° ′ ″
	55 18 30
	56 40 30
	57 12 40
	58 2 10
	4)227 13 50
Mean	56 48 27·5
Index Error	− 47·5
	2) 56 47 40
	28 23 50
Refraction	− 1 44·1
	28 22 5·9
Semidiameter of Sun	+ 16 7·5
	28 38 13·4
Parallax	+ 7·6
True Altitude	28 38 21

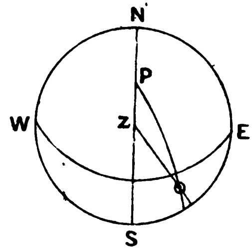


FIG. 89.

For formula, see note on p. 229.

	° ′ ″
Declination (p. ii. N.A.)	4 15 11 S.
Correction by Hourly Difference ..	+ 1 48
Sun's Declination	4 16 59
	90 00 00
Polar Distance	94 16 59

	M. S.
Eq. of Time (p. ii. N.A.)	10 32·97
Correction by Hourly Difference ..	+ 1·18
Red. Eq. Time ± to App. Time ..	10 34·15

* If A.M., subtract the Hour Angle from 24 hours and the remainder will be Local Apparent Time, reckoned from noon of the preceding day. If the sights are P.M. the Hour Angle is Apparent Time of the *given* day past noon.

† When no Log Sin square table is available, the Hour Angle can be found as follows: Take the sum of the four Logs as above and divide it by 2; the result is the Log Sin of half the Hour Angle in Arc; from the table of Log Sin take out the Arc corresponding thereto, and multiply it by 2; convert the Arc into time, and the result will be the Hour Angle.

N.B.—When the G.M.T. is known, the difference between L.M.T. found from this observation and the G.M.T. is the longitude in time from Greenwich.

Time by Equal Altitudes of Star.

a Scorpii (Antares).

NOTE.—If the Altitudes of the Star exceed 45° the effect of the change of Refraction and the correction for it may be neglected.

June 30th, 1905, Buabe. Approximate Long. 26° 40′ E. Ther.:—E. Obs. 78°; W. Obs. 70°. Bar.:—E. Obs. 30·2 inches; W. Obs. 30·1 inches.

		H. M. S.	H. M. S.
East Times		4 48 30 4 50 31 4 52 35	
Mean ..	3)	151 36 =	4 50 32
West Times		11 1 11 11 3 16 11 5 15	
Mean ..	3)	9 42 =	11 3 14
			2)15 53 46
*Approx. Chron. Time of Transit		=	7 56 53

COMPUTED TIME OF TRANSIT, M.T. CHRON.

		H. M. S.
G.S.T. of G.M.N. (p. ii. N.A.) ..	=	6 31 31·98
Correction for Longitude at 9·86 secs. per hour, or Acceleration (Table XVI., 'Hints')—E. +, W.	=	− 17·53
∴ L.S.T. of L.M.N...	=	6 31 14·45
R.A. of Star (or L.S.T. of Transit)	=	16 23 37·51
Sid. Int. between L.M.N. and Transit of Star	=	9 52 23·06
M.T. Equivalent (N.A.), or Retardation (Table XVII.) — Hours 9	=	8 58 31·53
Minutes 52	=	51 51·48
Seconds 23	=	22·94
†M.T. Interval between L.M.N. and Transit of star .. .. .. (i.e. L.M.T. of Transit.)	=	9 50 45·95

COMPUTED TIME, ETC., SIDEREAL CHRON.

		H. M. S.
R.A. of Star (or L.S.T. of Transit)	=	16 23 37·51
‡Corrected Chron. Time of Transit	=	7 56 53·12
Chron. Slow on L.S.T.	=	8 26 44·39

	° ′ ″
Observed Altitudes	34 50 0 35 5 0 35 20 0
	3)105 15 0
Mean Altitude	35 5 0

CORRECTION FOR REFRACTION.
(= East − West Corrections.)

		″
East Observations—		
Bar.	=	+ 0·75
Ther.	=	− 4·9
Total Corr. E.	=	− 4·15
West Observations—		
Bar.	=	+ 0·1
Ther.	=	− 3·4
Total Corr. W.	=	− 3·30
Difference (Δh)	=	− 0·85

i.e. excess (+) or reduction (−) of true Altitude at W. observations.

NOTE.—Signs must be carefully noted. For example: If E. Corr. is + and W. Corr. is − then Δh = E. − (− W.) = E. + W. and Δh is an "excess," being positive.

To find Δt (i.e. Time corr. for above Δh (p. 203 Chauvenet, Part I.): Take the difference between the extreme Times of the East (or West) Observations, and the change in Altitude during that time.

$$\text{Then } \Delta t = \frac{\Delta h \times \text{elapsed time in seconds}}{\text{change in Altitude in seconds}}$$

$$= \frac{0{\cdot}85 \times 245 \text{ secs.}}{1800''} = + {\cdot}12 \text{ sec.}$$

		H. M. S.
∴ Corr. for Refraction or Δt	= +	0·12
*Approx. Chron. time of Transit ..	=	7 56 53·00
‡∴ Corrected Chron. time of Transit ..	=	7 56 53·12
†L.M.T. of Transit	=	9·50 45·95
Chron. Slow on L.M.T.		1 53 52·83

If Δh is a reduction, i.e. negative, the Δt is positive and *vice versa*.

Error of Watch by Equal Altitudes of the Sun.

(For explanation of Formula, see 'Reeves' Trigonometry,' p. 65.)

February 13th, 1905. Longitude in Time, 40 sec. W.

TIMES OF ☉'S EQUAL ALTITUDES BY WATCH.

	A.M. H.	M.	S.		P.M. H.	M.	S.
	10	19	49		2	4	50
	10	21	54		2	2	37
	10	23	59		2	0	21
	10	26	18		1	58	10
	10	28	34		1	55	38
5)		120	34	5)	10	1	36
Mean of A.M. Times	10	24	6·8	Mean of P.M. Times	14	0	19·2
				Mean of A.M. Times	10	24	6·8
				2)	24	24	26
				Middle Time by Watch	12	12	13 =M.

	H.	M.	S.
Mean of P.M. Times	14	0	19·2
Mean of A.M. Times	10	24	6·8
Difference .. .. 2)	3	36	12·4
Half elapsed Time	1	48	6·2=h.

	H.	M.	S.
If the Watch is right for Apparent Time, it will show ..	12	0	0·00
But it shows	12	11	53·67
Therefore it is Fast for Apparent Time at place		11	53·67

	H.	M.	S.
	12	0	0
Equation of Time	+	14	24·56
If right for M.T. at Apparent Noon the Watch would show ..	12	14	24·56
But it shows	12	11	53·67
Therefore Watch Slow on Mean Time at place	0	2	30·89

	H.	M.	S.
February 13th, 1905	0	0	0
Longitude in Time			40W.
Greenwich Date at Apparent Noon	0	0	40

	°	′	″
☉'s Declination (p. i. N.A.) ..	13	28	36·0 S.
Corr. for Hourly Diff. (N.A.)		−	0·5
Corrected Declination ..	13	28	35·5
	90	00	00
N. Polar Distance	103	28	35·5

	M.	S.	
Equation of Time (p. i. N.A.)	14	24·56	
Corr. for Hourly Diff. (N.A.) ..	0	0	
Corr. Eq. of Time	14	24·56	(add. to App. T.)

N.B.—Here note if the Equation of Time is to be added or subtracted (to or from) App. Time.

Hourly Diff. of Declination (N.A.) ..	50″·26
Half elapsed Time .. .. ×	1·8
C =	90″·468

C ..	90″·468			log	1·956495	To find A
Lat.	51°	14′	15″·5	log tang..	0·095317	
	H.	M.	S.			
h ..	1	48	6·2	log cosec	0·342582	
A ..	247″·97			log =	2·394394	
C ..	90″·468			log	1·956495	To find B
Decl.	13°	28′	35″·5	log tang..	9·379570	
	H.	M.	S.			
h ..	1	48	6·2	log cotang	0·292366	
B ..	42″·5			log	1·628431	

A + B, when the Latitude and Declination are contrary names; and A − B when they are the same name, is the Equation of Equal Altitudes. Divide this Equation by 15, and the result is the Equation expressed in Time.

	H.	M.	S.
Middle Time by Watch	12	12	13·00
* Equation of Equal Altitudes ..		−	19·33
Time by Watch at App. Noon ..	12	11	53·67

* + When ☉'s P.D. is increasing, but − when ☉'s P.D. is decreasing.

Equal Altitudes of a Star on the same side of the Meridian, on different nights.—Observe the altitude of a star at any time, note the time and the altitude. After an interval of some days—for example, four days—set the index to the altitude noted, and take the time when the star attains it; then, as a star comes to the meridian exactly 3m. 55·91 secs. earlier every day, multiply this interval by the number of days elapsed, and subtract the product from the time when the first altitude was taken; the result will be the time the watch should show. Any difference between this result and the time the watch shows is the error for the interval, which, divided by the number of days, gives its daily rate; thus, if a watch showed 9h. 50m. 8 secs., when an observation of a star was taken June 20th, and on June 24th showed 9h. 34m. 10 secs., when the same star had the same altitude, its daily rate would be 3·6 secs. losing :—

	H.	M.	S.	
1st time by watch	9	50	8	
3 m. 55·91 sec. × 4 =	–	15	43·6	
Time watch should show..	9	34	24·4	
2nd time by watch	9	34	10	
Losing in 4 days			14·4	∴ daily rate 3·6 sec.

This observation should be taken when the star has a considerable altitude, so as to reduce the errors caused by refraction, and can only be used when a halt of some days is made, as any change in latitude would be followed by a change of altitude.

Rate.

It is but of little practical use to find the precise time of an observation unless it is transferred to the watch. By taking the difference between the time resulting from the observations, and that shown by the watch, the error of the latter is found.

The true time of any subsequent, or previous observation taken within a short time of the observation for time, can then be found by applying this known error to the watch time.

If, however, the time is required some days later, it is necessary to know the rate of the watch, and this is obtained by repeating the observation for time in the same spot after a few days, when the

difference of the errors, divided by the time elapsed between the observations, will be the rate of the watch.

	H.	M.	S.	
Thus, Error of Watch at Ujiji on Sept. 24th, 8 A.M., was	1	14	23	slow
" " " Sept. 29th, 8 A.M., was	1	15	17	"
Difference		5)	54	
Rate of Watch=			10·8	losing.

Then, supposing that observations for longitude, say, by occultations, were obtained on the 26th without being able to obtain observations for time on the same day, the time can be found by applying the rate to the previous error, thus:—

	H.	M.	S.	H.	M.	S.
Watch showed at time of observation of occultation about 10 P.M.				9	1	50
Error of Watch on 24th .. .. =	1	14	23			
2·6 days' rate = 28·1 secs. losing			28·1			
Error of Watch at time of occultation	1	14	51·1	1	14	51·1
True time at observation, 26th				10	16	41·1

Longitude by Meridian Distance.

The difference of longitude of two places is the difference of time between them at the same instant.

If therefore the time at one place can be transported, by means of a watch, to another place, and the true time at that second place obtained, the difference of those times is the difference of longitude between the two places.

This is accomplished in practice, by finding the errors of the watch at the two places, either by absolute, or equal altitudes, and the rate, in any case at one of them, though it is better to find it at both, and take the mean.

Rules.—The time at the place where the first observations were taken must be reduced by the mean rate and the interval to the same instant of time as when the observations were taken for error at the second place of observation. This is done by multiplying the mean rate by the interval of time (expressed in days and decimals of a day) that has elapsed between the last observation for error at the first station, and the first observation at the last station.

Error slow.—Suppose a case where the error of the watch at both stations was found to be slow on the local time, then, after reducing the error of the watch, as above, from the first station to the second, if the watch is less slow at the second station, the meridian distance will be West, because we have, by travelling to the West, reduced a slow error on the local time of the first station. On the other hand, if the error at the second station, after the above reductions, should be more slow, then the meridian distance will be East, because by travelling East we have increased a slow error on the local time of the first station.

Error fast.—If the error of the watch at both stations is fast, then (after reducing the time of the first station to the second station, as directed above) if the watch is less fast at the second station, the meridian distance will be East, because we must have travelled East to reduce a fast error on the local time of the first station; but if it is more fast at the second station, the meridian distance will be West, because we must have travelled West to increase a fast error on the local time of the first station.

Fast and slow errors combined.—When the watch at first station has a slow error on local time, and a fast error at second station, the meridian distance will be West, because we must have travelled West to have changed a fast error on the local time of the first station to a slow one at the second station; and when the watch at first station has a fast error on local time, and a slow error at the second station, the meridian distance will be East, because we must have travelled East to change a fast error on local time at the first station to a slow one at the second station.

If provided with a compass, a traveller should, in all cases, know if he had been making Easting or Westing.

The following are examples of these three cases:—

Example 1.

		H.	M.	S.	
Error of Watch at Mombasa, 8 A.M., July 14th	.. .. ..	2	18	32	slow
,, ,, ,, 9 A.M., July 20th	.. .. ..	2	17	14	,,
Interval 6·04 days	Difference =		1	18	
	6·04)			78	
	Daily rate =			12·91	gaining.

		H.	M.	S.	
Error of Watch at Taveta, 4 P.M., July 25th	.. ..	2	8	5	slow
" " " 8 A.M., July 30th	.. ..	2	6	48	"
Interval 4·67 days	Difference =		1	17	
	4·67)			77	
Daily rate	=			16·5	gaining
Former daily rate..	=			12·9	"
			2)	29·4	
Mean daily rate				14·7	"

		H.	M.	S.	
Error of Watch at Mombasa, 9 A.M., July 20th	=	2	17	14	slow
5·3 days' mean rate	=	−	1	18	gaining
Error of Watch at Mombasa, 4 P.M., July 25th	=	2	15	56	slow
" " Taveta, 4 P.M., July 25th	=	2	8	5	
Meridian distance, or difference of Longitude between Mombasa and Taveta	=		7	51	= 1° 57′ 45″

and as the watch is less slow at Taveta than at Mombasa, Taveta is west of Mombasa.

		°	′	″	
The Longitude of Mombasa being		39	40	00	E.
Meridian distance, west		1	57	45	W.
Longitude of Taveta	=	37	42	15	E.

Here we have supposed the rate to be obtained at both places. If, however, it was only ascertained at one end, that rate would have to be used. In the case supposed the result would be a difference of 10 seconds in the determination of the longitude of Taveta, or 2′ 30″ of longitude.

Example 2.

		H.	M.	S.	
June 15th, 9 A.M.—Error of Watch at Manos	.. ..	3	56	20	fast
June 20th, 3·56 P.M. " " "	.. ..	3	58	10	"
	Difference =		1	50	

DAYS. SECS. SECS.
Interval: 5·29) 110·0000 (20·79 = daily rate gaining.
105 8

4 200
3 703

4970
4761

	H.	M.	S.	
June 27th, 4 P.M.—Error of Watch at Concacão	3	48	5	fast
July 3rd, 8 A.M. „ „ „	3	49	58	
Difference =		1	53	

DAYS. SECS. SECS.
Interval: 5·66)113·0000(19·96 daily rate gaining.
56 6

5640
5094

5460
5094

3660
3396

	SECS.
Daily rate at Manos	20·79
„ „ Concacão	19·96
	2)40·75
Mean daily rate =	20·37

	H.	M.	S.	
Error of Watch at Manos, June 20th, 3.56 P.M.	3	58	10	fast.
7 days' mean rate gaining	+	2	22·59	
Error of Watch at Manos, June 27th, 4 P.M.	4	00	32·59	
„ „ Concacão „ „	3	48	05	fast.
Mer. distance or diff. of Long. between Manos and Concacão	0	12	27·59	

As the Watch is less fast at Concacão than at Manos, Concacão is East of Manos.

	°	′	″	
Longitude of Manos	60	00	00	W.
Meridian distance East	3	6	54	E.
Longitude of Concacão	56	53	6	W.

Example 8.

	H.	M.	S.	
May 12th, at 8.30 A.M., at Bandar Abas, Watch	1	10	20	fast.
May 16th, at 4.10 P.M.	1	9	52	„
Difference =	0	0	28	

DAYS. SECS. SECS.
Interval: 4·33) 28·0000 (6·46 = daily rate losing.
25 98

2 020
1 732

2880
2598

	H.	M.	S.	
May 21st, at 3.30 P.M., at Forg, Watch	1	15	2	fast.
May 25th, at 8.30 A.M. ,, ,, ...	1	14	41	,,
Difference =	0	0	21	

DAYS. SECS. SECS.
Interval: 3·71) 21·0000 (5·66 = daily rate losing.
18 55
2 450
2 226
2240

	SECS.
Daily rate at Bandar Abas	6·46
,, Forg	5·66
2)	12·12
Mean daily rate =	6·06

	H.	M.	S.	
Error of Watch at Bandar Abas at 4.10 P.M., May 16th ..	1	9	52	fast.
5 days' mean rate		–	30·3	losing.
Error of Watch at Bandar Abas at 3.30 P.M., May 21st ..	1	9	21·7	
,, ,, Forg at 3.30 P.M., May 21st	1	15	2	
Mer. dist. or diff. of Long. between Bandar Abas and Forg	0	5	40·3	= 1° 25′ 4″·5

As Watch is more fast at Forg than at Bandar Abas, Forg is West of Bandar Abas.

	°	′	″	
Longitude of Bandar Abas	56	18	00	E.
Meridian distance West	1	25	4·5	W.
Longitude of Forg .. .. =	54	52	55·5	E.

This method can be used at *any part of a journey* to measure the differences of longitude between two places. If the longitude of one of the places has been fixed by any reliable methods, the longitude of the other is known at once. If not, the longitude of either of the places may be fixed hereafter, and the longitudes of the places whose meridian distances have been measured will be in connection with it, and not be scattered about with large individual errors, as would be the case were they determined separately by one or two observations.

Telegraphic Difference of Longitude.

For a description of the refined determination of differences of longitude by telegraph for geodetic purposes, by means of chronographs, the reader is referred to any standard work on geodetic methods. The following is the simple means used to obtain telegraphic differences of longitude with sufficient accuracy for map making.

Let A and B be two stations which are connected by telegraph, and of which it is required to determine the difference of longitude.

Arrangements must first be made to ensure direct communication between A and B; this may involve the use of relays. The line must be free of all traffic during certain hours of the night, and there must be a telegraph operator at each end.

At each end there must be a good chronometer, one of these should be a mean time chronometer and the other a sidereal time chronometer. The reason for this is that if both were sidereal time or both mean time chronometers the intervals between the beats of the chronometer would be constant and there would be no coincidences.

The chronometer should be on the same table (in tent, hut, or house) as the telegraph key, and close to it, so that the person sending signals can easily read the chronometers.

Before commencing the exchange of signals, a programme should be arranged between A and B.

A convenient programme is as follows:—

Signals to be exchanged on three nights.

Each night's work to consist of at least one set of signals sent in each direction.

Unsatisfactory sets to be repeated.

Each set of signals should be preceded by a rattle on the keys about thirty seconds before the set begins. Each set should end with a rattle. A message should be sent at the end of a set, to ask if it was received all right.

Each set of signals to last five minutes.

Each set to begin at a minute	0	seconds.
Succeeding signals to be sent at	10	,,
	20	,,
	30	,,
	40	,,
	—	
	0	,,
	10	,,
	etc.	

Omitting the 50 seconds.

When the key is depressed to send a signal it should be kept down for two seconds.

Receiving.—The chronometers should beat half seconds, and in receiving signals it is necessary to count mentally the beats of the chronometer, thus: One, half, two, half, three, half, etc. If now the signal from the other end should arrive, say, between half and two, the person receiving must judge whether it was 1·6, 1·7, 1·8 or 1·9; if he is doubtful he should say 1·8. It requires a little practice to judge the interval.

If the chronometers beat half seconds, a coincidence will occur every three minutes; at a coincidence the chronometer-beat and the signal will sound together, the receiver will then say "up"; the beat and the signal will sensibly coincide two or three times running.

Before and after exchanging signals, observations for time should be taken. These observations for time should be made either with a portable transit instrument or with a theodolite. If with the former, two N. stars and two S. stars before and the same number after. If with a theodolite, two E. and two W. stars before and the same number after.

The box-chronometer should not be moved from the table on which it rests during the operations; any movement will tend to give it an irregular rate.

Its error should be determined by transit instrument, or theodolite, as laid down; each moment of transit or intersection being referred to the chronometer in one of the following ways:—

By having a recorder at the chronometer and: (1) Fitting up a temporary telegraph line a few yards long from instrument to hut, and sending signals by key. (2) By shouting "up" to recorder. (3) The time may be transferred by stop-watch; this is only suitable for use with a theodolite, which must be near the instrument. The next morning, after an interchange of signal, each station should send a message to the other station: "My local mean (or sidereal) time of first signal sent me..." (to tenths of seconds). "My local mean (or sidereal) time of first signal received was..."

The list of received signals should now be inspected; there should be a slow progressive increase or decrease in the decimals; any obvious mistake should be corrected.

The difference between the mean of the corrected local time of receiving and sending is the difference of longitude in time.

This is burdened with two errors (in addition to instrumental errors):

(1) *Rate of transmission of signal along the wire.*—This is eliminated by sending the same number of times in each direction, and is very small.

(2) *Personal equation.*—Every observer records a transit intersection or signal a little too early or too late.

This error is best eliminated by exchange of observers from one end of the line to the other when half the work has been completed. This is not usually practicable in topographical work.

In view of the existence of personal equation, it must be expected that a telegraphic difference of longitude, determined as above described, will be in error ·3 to ·5 of a second of time, or, in equatorial regions, 150 to 250 yards.

Longitude by the Occultation of a Star.

This is the best of the absolute methods of finding longitude, when a theodolite or sextant is available for ascertaining the local time.

The moon in its monthly revolutions round the earth frequently passes between the earth and a fixed star so as to intercept a spectator's view of the latter; the disappearance of a star from this cause is called an *immersion*, and its reappearance from behind the moon is called an *emersion*. A list of these phenomena is given in the 'Nautical Almanac,' with the limits in latitude beyond which a star cannot be occulted by the moon.

The 'Nautical Almanac' gives the Elements of Occultations as they would be seen from the centre of the earth, and although the limits of latitudes between which the star may be occulted are stated, this does not mean that the star will be occulted as seen from every place within the given limits, but rather that outside these limits the occultation is impossible.

The first point for the observer to consider is whether the moon will be above the horizon at the time of Conjunction in Right Ascension. This can easily be determined by applying the assumed longitude in time to the G.M.T. of conjunction in R. A. of the moon and star, which he will find among the Elements of Occultations in the 'Nautical Almanac,' *adding* the longitude in time if it be *East*, and *subtracting* if *West;* and by reference to the hour angle at the G.M.T. of conjunction in Right Ascension, which is now given in the 'Nautical Almanac.' He can then ascertain whether the occultation will take

place in daylight, in which case it cannot be observed, if the star, as is most frequently the case, is one of small magnitude. The general effects of parallax must be taken into consideration. Parallax will accelerate the occurrence of the occultation when the moon is east of the meridian, and retard it when west; and under certain conditions this acceleration or retardation may amount to more than an hour and a half, or it may so affect the apparent relative positions of the moon and star that the occultation will not take place at all at that station. Further, the star's apparent path may so approach a tangent to the moon's disc as to render the results obtained from the observation unreliable. To prevent loss of time and disappointment, therefore, the circumstances of the occultation should be predicted before-hand. The traveller will then know whether the occultation will take place at his station, the approximate local mean time of immersion and emersion, and the position on the moon's limb where the star will disappear and reappear. The most practical method of predicting the circumstances of an occultation for travellers is doubtless that devised by Colonel S. C. N. Grant, R.E., and adapted to the data now given in the 'Nautical Almanac' by Mr. A. C. D. Crommelin, which is described in the following pages.

If a traveller neglects to predict the circumstances of an occultation he wishes to observe, he must compute the local time of the phenomenon by applying the assumed longitude in time to the G.M.T. of Conjunction in R. A. of the moon and star, which he will find among the Elements of Occultations in the 'Nautical Almanac,' *adding* the longitude in time if it be *East*, and *subtracting* if it be *West*. An hour before the time so found, he should point his telescope to that limb of the moon by which the star will be occulted; it is necessary to take this precaution, as his time may be in error, and the effects of parallax may accelerate or retard the occultation at his station according as the moon is east or west of the meridian. The moon will be seen to approach the star from west to east, until its eastern limb will reach the star and occult it; note the instant when this takes place. After a certain interval the star will reappear on the other side of the moon; note this time also. Either of these observations is sufficient to determine the G.M.T., and, combined with observations for Local Mean Time, the longitude, in the manner shown in the example, but the best results are obtained from an *immersion* on the dark limb of the moon about first quarter. At or

near full moon a star occulted by the bright limb is not so easy an observation. The description of a telescope suitable for this observation is given on p. 16. The example given (p. 254) is computed by Raper's rule and tables.

There is but little difficulty in recognising the star, as the moon only moves about its own diameter among the stars in an hour, and there is ample time after the star and moon are in apparent close proximity to make sure of the star. Before, or immediately after this observation, East and West star observations should be taken to find the error of the watch on Local Mean Time.

Prediction of an Occultation.

Having selected what appears to be a suitable star, as just described, copy down on a sheet of paper the Elements of the Occultation from the 'Nautical Almanac,' noting especially the coordinates q_0, p and q', the G.M.T. of Conjunction in Æ. and the hour angle. This is the hour angle for the Greenwich Meridian, and to find the corresponding hour angle for the local meridian all that is necessary is to apply to this the longitude in time. Previous to 1906 the hour angles were not given in the 'Nautical Almanac,' and had to be computed as shown in the example (p. 252). The hour angle thus found is the local hour angle at T_0 (Diagram No. 1),* and those at any other hours can, of course, be readily obtained from this one by simply adding or subtracting one or more hours as required. The hours to select can be found from the following table:—

	Times to select.
Hour angle E. at T_0 exceeding 2^h	T_{-2} and T_{-1}
" " " between 2^h and 0^h	T_{-1} and T_0
Hour angle W. at T_0 between 0^h and 2^h	T_0 and T_1
" " " exceeding 2^h	T_1 and T_2

To Draw the Moon's Geocentric Path.—The next step is to draw a line on Diagram No. 1 to show the moon's geocentric path.

O, the middle of the diagram, represents the star. Measure a distance

* Diagrams Nos. 1 and 2 are in pocket at end of this volume.

OG_0 equal to q_0 on the vertical line through O; taking the thicker numbered lines 1, 2, 3, etc., as tenths, and the smaller subdivisions as hundredths. When q_0 is +, G_0 is above O; when −, below O. Then draw G_0M horizontally to the left equal to p', and MG_1, vertically up or down, equal to q'. When q' is +, G_1 is above M; when −, below. Join G_0G_1, produce the line in both directions, and mark off a series of points at equal intervals, G_{-2}, G_{-1}, G_0, G_1, G_2.

Then the line G_{-2}, G_2 represents the geocentric path of the moon, and G_{-2} is the geocentric place of the moon's centre at time T_{-2}, i.e. two hours before T_0, the G.M.T. of Conjunction in Æ, and similarly for the other points.

Having thus drawn the geocentric path of the moon on Diagram No. 1, i.e., the path that the moon would follow amongst the stars as seen from the centre of the earth, the next thing is to draw the *apparent path* of the moon for the same time, or the path that the moon would actually be seen to follow amongst the stars by an observer situated on the earth's surface at the given latitude and longitude. But before this can be done it is necessary to find the amount by which the moon has been moved in the heavens by parallax, or the measures of the *Parallaxes in Declination* and *Right Ascension*, as they are named. To do this, turn to diagram No. 2.

This diagram represents an orthographic projection of the sphere, showing parallels of latitude and hour circles; the line O O represents the projection of the equator, and the projections of the parallels of latitude are drawn at intervals of 5°. The divisions on the circumference of the circle, however, give the positions of parallels to each degree, and as the intervals between these divisions can be divided into four parts, latitude can be plotted to 15′.

The hour circles are drawn only on the eastern half of the circle, and a portion of the north-west quadrant. They are numbered in two ways—one from O at the centre to VI. at the east circumference; and the other from O at the circumference to VI. at the centre, and continued to VII. and VIII. beyond the centre. The use of these two systems of numbering will be explained hereafter. Where the space permits, the intervals between the hour circles have been subdivided into spaces representing five minutes; the hour nearest the circumference is divided only into spaces of fifteen minutes. Near the centre of the circle these divisions can be subdivided by eye into five parts, each part representing one

minute, which may be taken as the limit of accuracy to which the hour angle can be plotted, and consequently need be calculated. The accuracy, however, decreases as the divisions become smaller near the circumference and in high latitudes.

To find the Parallax in Declination.—Plot on the diagram the position of the place of observation from its known latitude and the hour angle, counting the hour angle from *right to left*—that is, from the circumference towards the centre. Call this point A. Draw a straight line through the centre of the circle and that division of the circumference representing the star's Declination, above or below the line O O according as the declination is north or south, and in the same side of the circle as that from which the hour angles commence to count. Denote this line by C B.

The length of a line next drawn from the point A perpendicular to the line C B, produced if necessary, is a measure of the Parallax in Declination. Repeat this operation to find the Parallax in Declination for the second hour required. In the example given the two hours are T_0 and T_{-1}, and the lines A D and A′ D′ represent the measure of the Parallax in Declination for these two hours.

To find the Parallax in Right Ascension.—The diagram for this purpose represents a similar projection on a vertical plane at right angles to the former. Measure off on the latitude parallel the hour angles at the two selected times, starting from the central vertical line and going towards the right. If the hour angle exceeds 6^h, first move out to the extreme right-hand edge of the parallel, and then count inwards again from that point. The distances of the two points thus obtained from the central vertical line are the Parallaxes in Right Ascension. The lines *a b* and *a c* represent the measures of the Parallax in Right Ascension for the hours T_0 and T_{-1} in the example.

To Draw the Moon's Apparent Path.—Having found the measures of the Parallaxes in Right Ascension and Declination, the next operation is to apply these measures to the two selected positions of the moon in its geocentric path already shown on diagram No. 1, and thus obtain the apparent path of the moon, or the path that it will be seen to follow by the observer. This is done as follows:—

(1.) Take the measures of each of the lines representing the Parallaxes in Declination from diagram No. 2 in a pair of compasses, and set them

off on the north and south vertical lines on diagram No. 1 from the hours of the moon's geocentric path selected. (These lines are shown by G_0, x, and G_{-1}, x' in the example.) When the moon's Declination is south of the observer's latitude this line is drawn *down* towards the south on the diagram, and when to the north it is drawn *up* towards the north.

(2.) Next take the measures of the Parallaxes in Right Ascension from diagram No. 2, and set them off from x and x' (the terminations of the lines from G_0 and G_{-1} in the example). When the hour angle is east, parallax places the moon further east, so in that case the lines must be set off to the *left* on the diagram (No. 1), and when the hour angle is west the moon will be moved further west by parallax, in which case the lines must be drawn towards the *right* on the diagram.

(3.) The ends of these lines representing the Parallaxes in Right Ascension thus laid down upon diagram No. 1, and indicated by T_0 and T_{-1}, are the approximate positions of the moon in her apparent path, corresponding to G_0 and G_{-1}, the positions in her geocentric path. Straight lines joining these, as G_0, T_0, and G_{-1}, T_{-1}, will therefore represent small sections of circles of altitude, the length of these lines the measures of the parallax in altitude, and the angle that these lines make with the vertical N. and S. lines in the diagram the angle between the vertex and north (or south) point of the moon in each case.

Next draw a straight line between the points representing the moon's position in her apparent path (T_0, T_{-1} on diagram), and this will show the apparent path of the moon in her motion in Right Ascension from W. to E., and the points where this line enters and leaves the graduated circles in the centre of the diagram will furnish the means of obtaining the approximate times of disappearance (or immersion) and reappearance (or emersion) of the occultation respectively, as follows :—

To find the Times of Disappearance and Reappearance.—T_0, on diagram No. 1, is the moon's position in her apparent path at G.M.T. of Conjunction in Æ which is given in the 'Nautical Almanac,' and the length of line between the various T's (T_{-1}, T_0, T_1, etc.) represents the movement of the moon in her apparent path in one hour of time. In the example given T_{-1} equals the position of the moon one hour previous to the G.M.T. of Conjunction, or 7h. 43m. 4sec. Since T_{-1}, T_0 is the movement in one hour, and the moon's centre is at the point where the

line strikes the graduated circle at disappearance and reappearance, it is merely a matter of simple proportion to find the time of disappearance and reappearance; but to simplify the matter and save computation, the time scale in the left-hand lower corner of diagram No. 1 has been constructed. To use this, take the measure of the line showing one hour's movement (as T_{-1}, T_0) and draw a line on the time scale where one hour is equal to this measure (as A B), then with the compasses measure the distance from the hour preceding the circle, or to the right of it (as T_{-1}), to where the moon's path cuts the circle, and take the number of minutes equal to this measure (as B, C) on the line A B, and this will give the number of minutes to add to T_{-1} (or one hour before the G.M.T. of Conjunction in Æ), to give the time of disappearance. This is the G.M.T. of disappearance or immersion at the observer's position, and to obtain from it the Local Mean Time the longitude in time must be subtracted if it is W. and added if E.

The L.M.T. of reappearance, or emersion, can, of course, be obtained in a similar manner.

To find Angles from North Point and Vertex of the Moon.—The points on the graduated circle (diagram No. 1) where the moon's apparent path enters and leaves this circle, show the position of the moon's centre at disappearance and reappearance respectively, and the angles read on the circle at these points give at a glance the angles that the star makes with the north point of the moon's disc at disappearance and reappearance measured round from N. by E. to S.

As previously stated, the straight lines G_{-1}, T_{-1} and G_0 and T_0 represent the measures of the Parallax in Altitude, and since parallax lowers a heavenly body directly in a circle of altitude, they also represent small sections of a circle of altitude. Further, since the vertex is the top of the moon, or the point where the altitude circle passing from the zenith first strikes the moon's disc, the angle that this line at each hour makes with the N. and S. lines on diagram No. 1 will be the angle between the vertex and N. point at that hour. By simple proportion, then, it is easy to find what this angle would be at the points where the moon's path enters and leaves the graduated circle, which are the positions of the moon's centre at disappearance and reappearance, and by adding this angle to or subtracting it from the angle from N. point already obtained, the angles from vertex can be readily found.

Prediction of Occultation.

Elements of Occultation (44 *Leonis*), taken from 'Nautical Almanac.'

Date.	Star's Name.	Magnitude.	G.M.T. of Conjunction in R.A.	q_0	p′	q′	Limits of Latitude.	
15th April, 1905.	44 Leonis.	6·2	h. m. s. 8 43 4	+0·6084	·5820	−·1668	78° N.	1° N.

✡ Declination 9° 15′ 54″ N. *Redhill*—Latitude 51° 14′ 4″ N.
Approx. longitude 45 secs. W.

		H.	M.	S.	
(1) To find Hour Angles	G.M.T. of Conjunction	8	43	4	
	Sidereal Time of G.M.N. (p. ii. N.A.) ..	1	31	54	
	Acceleration for G.M.T. of Conjunction (8h. 43m. 4 sec.)	+	1	26	
	R.A. of Meridian	10	16	24	
	R.A. of Star	10	20	16	
	Star's E. Hour Angle at Greenwich.. ..		3	52*	
	W. Longitude in Time..	+		45	
	Star's E. Hour Angle at Place = T_0.. ..		4	37	E.
	” ” ” T_{-1}	1	4	37	”
(2) At Disappearance or Immersion at Place..		H.	M.	S.	
	G.M.T. of Conjunction in Æ (T_0)	8	43	4	
	Subtract 1 hour	1	0	0	
Angle from N. Point .. 99°	T_{-1}	7	43	4	
Angle between N. point and Vertex 11	Addition from Scale to find G.M.T. of Disappearance	+	20	0	
Angle from Vertex .. 110	G.M.T. of Disappearance	8	3	4	
	Longitude in Time W.	−		45	
	L.M.T. of Disappearance	8	2	19	
(3) At Reappearance or Emersion..		H.	M.	S.	
	G.M.T. in Conjunction	8	43	4	
	From Scale	−	25	28	
Angle from N. Point .. 302°					
Angle between N. Point and Vertex 9	G.M.T. of Reappearance	8	17	36	
	Longitude in Time W.	−		45	
Angle from Vertex .. 293	L.M.T. of Reappearance	9	16	51	

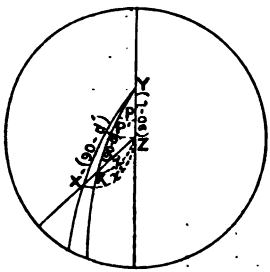
* This Hour Angle is now given in the "Nautical Almanac." It appears for the first time in 1906.

The Computation of the Longitude from an Occultation of a Star.—Although an approximate graphic method is sufficiently accurate for the prediction of an occultation, since an observer always allows a broad margin of time to prepare for the observation, afterwards when the observation has been taken, and it is required to obtain the longitude from it, the most rigorously correct computation is necessary.

A table of proportional logarithms, although useful, is not absolutely necessary, and there is a note on the form stating how the computation can be performed without it.

When a planet is occulted the computation is the same as for a star, except that its position has to be corrected to the approximate G.M.T. of observation.

There is not space in these 'Hints' to describe the theory of the following computation, but it is given in Reeves' Trigonometry. However, the following diagrams, with the explanations, will help to make the matter clear :—



Y = celestial pole.
Z = zenith.
X = true place of moon.
X' = apparent place of moon as affected by parallax.
P = true hour angle.
P' = apparent hour angle.
z = true zenith distance.
z' = apparent zenith distance.
d = true declination of point of contact of moon's limb with star.
d' = apparent declination of point of contact of moon's limb with star.
l = geocentric latitude.
$z'-z$ = parallax in altitude.
$YX'-YX$ = parallax in declination.
$P'-P$ = parallax in right ascension.

FIG. 90.

The Moon's Right Ascension and Declination as given in the 'Nautical Almanac' are, of course, computed several years in advance, and when the date arrives it is often found that they are slightly discordant with the positions as actually observed at Greenwich. To obtain the best results in longitude, therefore, before the final computation is made, corrections should be obtained from Greenwich Observatory and applied to the N. A. positions of the moon.

Care must be taken to apply the "Reduction to Date" to the Star's Right Ascension and Declination as given in the 'Nautical Almanac' list of Occultation Stars, remembering that the correction to the Declination is to be applied algebraically.

Computation of the Longitude from an Occultation of a Star. (44 *Leonis, E. of Meridian.*)

April 15th, 1905. Redhill.

Preparation of Data.

	H.	M.	S.
Time by Watch of Immersion or Emersion	8	2	38
Error of Watch (fast) on Mean Time at Place .. .. .. −			37·93
Mean Time at Place	8	2	0·07
Approx. Long. in Time .. +			45
Approximate G.M.T.	8	2	45·07

	′	″
☽'s Semid. Noon ..	16	17·21
P. iii. N.A. Midt. ..	16	23·69
12 hourly diff. .. =		6·48
Corr. for G.M.T. .. =		4·34
Semid. Noon	16	17·21
☽'s Semid. at G.M.T. =	16	21·55

	°	′	″
Latitude	51	14	4
Reduction (XX.)		11	27·95
Geocentric Lat. ..	51	2	36·05

	′	″
☽'s Hor. Par. Noon	59	40·26
☽'s Hor. Par. Midt.	60	4·03
12 hourly diff. .. .. .. =		23·77
Corr. for 12 Hourly Diff. for G.M.T. .. .. =		15·93
☽'s Hor. Par. Noon	59	40·26
☽'s Hor. Par. corr. for G.M.T.	59	56·19
Correction for Lat. (XVIII.) ..		7·37
☽'s Reduced Hor. Par. .. .. =	59	48·82

Month. Day.		H.	M.	S.
Sidereal Time (p. ii. N. A.)		1	31	53·77
Acceleration for G.M.T. (XVI.)	h. =		1	18·85
	m. =			·33
	s. =			·12
Mean ☉'s R.A.		1	33	13·07
Mean Time at Place .. .. +		8	2	0·07
R.A. of Meridian .. .. =		9	35	13·14
✱'s Right Ascension		10	20	16
✱'s Hour Angle .. .. =			45	02·86
		°	′	″
✱'s Declination		9	15	54 N.

	°	′	″
☽'s Declination April 15th at 8 hours	9	59	31·90
* Variation of Decl. in 1 m. × mins. of G.M.T. =			27·39
Reduced Declination .. .. =	9	59	04·51

For Parallax in Declination.

	°	′	″		
☽'s Reduced Hor. Par.	0	59	48·82	Pro log	·478400
Geocentric Latitude ..	51	2	36·05	Log cosec	·109232
✱'s Declination ..	9	15	54	Log secant	·005703

Arc A = 45′ 55″ = Pro log = ·593335
Arc C − 00 00
A—C = 45 55

.. ..	·478400
.. .. .. Log sec	·201534
.. .. .. Log cosec	·793175
✱'s Hour ∠ Log sec	·008445

Arc B = 5′ 56·25″ = Pro log = 1·481554

.. ..	·478400
.. .. Log sec	·201534
✱'s Hour ∠ Log cosecant	·709311
‖ Sum of 3 Logs. .. .. =	1·389245
×	2
	2·778490
Constant .. .. +	1·582000
✱'s Decl. Log cotan .. +	·787473
Arc C = 0′ 00″ = Pro log. =	5·147963

	°	′	″
✳'s Declination	9	15	54
A—C + when Lat. and Decl. same name; − „ „ „ different name	+	45	55
	10	1	49
B − when Hour ∠ is *less* than 6 hours; + when *more*	−	5	56·42
Prepared Declination .. .. =	9	55	52·58

For Parallax in Right Ascension and Greenwich Mean Time.

PART I.

	° ′ ″		
Prepared Declination	9 55 52·58	Log cosine ..	9·99344
☽'s Declination	9 59 04·51	Log constant	1·17610
Difference	3 11·93		
☽'s Semidiameter ..	16 21·55		
Difference ..	13 9·62	½ Pro log ..	·56799
Sum	19 33·48	½ Pro log ..	·48198
	M. S.		
Part I. =	1 5·15 = Pro log		=2·21951

PART II.

.. .. Log cosine	9·99344
.. .. Log constant	= 1·17610
‖ Sum of 3 Logs used to find C.	1·38925
Part II. 0 M. 29·83 S. = Pro log	2·55879

	H.	M.	S.
✳'s R. A.	10	20	16
Part I.—If Immersion .. .. −		1	5·15
	10	19	10·85
Part II.—When ☽ E. of Meridian. .. .. .. −			29·83
☽'s Right Ascension =	10	18	41·02

		H.	M.	S.			
	(1) ☽'s R. A. (thus found)	10	18	41·02			
Hour for which (2) was taken from N.A. = 8 h.	(2) ☽'s R. A. preceding hour	10	18	34·38			
	(3) ☽'s R. A. following hour	10	20	55·98		Constant	0·47712
	Difference between (1) and (2)			6·64		Pro log	3·21242
	Difference between (2) and (3)		2	21·60		Ar. co. pro log	8·11766
			2	48·35	=	Pro log .. .. =	1·80718
	Hour of (2) .. .. +	8	0	0			
** For extreme accuracy, re-compute Part I. with this G.M.T., and the result will be the true G.M.T., possibly some seconds different from the first obtained.	** G.M.T.	8	2	48·35			
	Mean Time at Place	8	2	00·07			
	Longitude in Time			48·28	=	12′ 4·2″ W.	

The Roman numerals refer to the Tables at the end of this volume.

NOTE.—When no special table is available the Proportional Logarithms for this computation can be obtained by subtracting the common log of the time or arc in seconds from 4·03342 (the log of 10,800, the number of seconds in 3 h. or 3°); and *vice versa* the time or arc corresponding to any Proportional Log can be found by subtracting the Proportional Log from 4·03342 to obtain the common log, and the number corresponding to this will be the required time or arc in seconds.

Observations for Azimuth and Error of Compass.

January 12th, 1905, Pilgrim's Path, Reigate. Lat., 51° 15′ 5·9″ N. Long. (approx.), 50 secs. W. Ther., 35°. Bar., 29·8 inches. R.O., Leith Hill Tower (S. of star). Magnetic bearing of R.O. N., 249° 50′ E.

	Times by Watch.			Angle between R.O. and ✡ (α Andromedæ) W. of Meridian.				Means of A and B Verniers.			Altitudes.				Means of C and D Verniers.			E.	O.
	H.	M.	S.		°	′	″	°	′	″		°	′	″	°	′	″		
F. L.	7	20	13	A	15	14	20	15	14	20	C	52	29	00	52	27	45	10·5	11
				B	195	14	20				D	52	26	30					
F. R.	7	24	1	A	196	11	50	16	12	5	C	38	9	50	51	49	40	12	9·5
				B	16	12	20				D	38	10	50					
F. R.	7	26	39	A	196	52	40	16	53	5	C	38	34	30	51	26	25	12	9·5
				B	16	53	30				D	38	32	40					
F. L.	7	29	39	A	17	44	40	17	44	25	C	51	4	30	51	3	25	10	11·5
				B	197	44	10				D	51	2	20					
F. L.	7	31	42	A	18	15	50	18	15	45	C	50	46	20	50	45	15	10	11·5
				B	198	15	40				D	50	44	10					
F. R.	7	34	51	A	198	58	30	18	58	45	C	39	45	30	50	13	20	12·5	9·5
				B	18	59	00				D	39	47	50					
							6)	103	18	25				6)	307	45	50	67·0	62·5
																		62·5	
								17	13	4·17					51	17	38·16		
											level corr.					—	7·14	12) 4·5	
															51	17	31·02	0·37	
																		19·3	value of 1 division of level
																		111	
																		333	
																		37	
																		7·141	level correction.

The computation of the Azimuth from this form is given on the next page.

When observations of the sun are taken for Azimuth all corrections for semidiameter are obviated, both as regards vertical and horizontal angles, if the altitudes are taken diagonally in four quarters as shown in this diagram

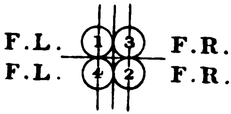


FIG. 91.

It is obvious that any pair will bring the observation to the sun's centre.

Azimuth by Sun or Star with a Theodolite.

January 12th, 1905. Altitudes of *a Andromedæ*, West of Meridian. Pilgrim's Path, Reigate.—Lat. (ϕ) 51° 15′ 5·9″ N. (Mean of N. and S. star observations.) Approx. Long. 50 secs. W. Ther. 35°. Bar. 29·8 in. R.O. Leith Hill Tower (S. of star). Magnetic Bearing of R.O. N. 249° 50′ 0″ E. (For observations see preceding page.)

$$\text{Tan}\,\frac{A}{2} = \sqrt{\text{Sec}\ s\ \text{Sec}\ (s - p)\ \text{Sin}\ (s - \phi)\ \text{Sin}\ (s - h)} \text{ and } s = \frac{h + \phi + p}{2}.$$

A = Horizontal Angle between the Elevated Pole and Star.

h = True Altitude.

In this formula the Latitude (ϕ) should be taken with the positive sign whether N. or S. and the Polar Distance (p) is then to be reckoned from the Elevated Pole.

Elements.

		′	″
Refraction due to Alt.	=	0	46·8
Correction for Bar. ..	=	−	0·3
Correction for Ther. ..	=	+	1·6
Refraction	=	0	48·1
Hor. Par. (p. i. N.A.) ..	=		
× Cos. Altitude	=		
∴ Parallax in Alt. ..	=		

Computation.

		°	′	″
From Angle Book Mean Obsd. Alt. ..	=	51	17	31·0
Corr. for Refraction ..	= −			48·1
Corr. for Semi-diam. ±	=			
Corr. for Parallax ..	= +			
True Altitude (h)	=	51	16	42·9
Latitude (ϕ)	=	51	15	5·9
Polar Distance (p) ..	=	61	25	57·4
	2)	163	57	46·2
	s =	81	58	53·1

With Sun Observations only. — Omitted with M.T. Chron.

	H.	M.	S.
G.S.T. of G.M.N. (p. ii. N.A.) .. .. =			
Corr. for Long. at 9·86 secs. per hour (or Accel. Table No. XVI.) (+ W. − E.) =			
L.S.T. of L.M.N. .. .. =			
Mean of Times (Angle Book) .. .. =			
∴ Sid. Int. from L.M.N. =			
Retardation (Table XVII.) or M.T. Equivalents (Table in N.A.) h. m. s.			
∴ L.M.T. of Observation .. = (If M.T. Chron. used this is taken direct from Angle Book.)			
Long. E. (−) or W. (+) .. ± =			
G.M.T. of Observation .. .. =			
∴ Int. from G.M.N. in hours =			
	°	′	″
Decl. (δ) at G.M.N. (N. or S.) ± =			
Hourly Var. (p. i. N.A.) × Int. from G.M.N. ± =			
Decl. (δ) of star.. .. .. =	28	34	2·6 N.
	90	00	00·0
∴ Polar Distance (p) .. .. .. =	61	25	57·4 N.

Note.—"p" is reckoned from Elevated Pole, therefore if ϕ and δ are of different names "δ" will be negative and $p = 90 + \delta$.

	°	′	″		
$s = $	81	58	53·1	Log sec =	0·855442
$s - p = $	20	32	55·7	Log sec =	0·028551
$s - \phi = $	30	43	47·2	Log sin =	9·708411
$s - h = $	30	42	10·2	Log sin =	9·708068
				2)	20·300472

$$\text{Log tan } \frac{A}{2} = 10\cdot150236$$

	°	′	″
$\frac{A}{2} =$	54	43	6
		×	2
A	109	26	12·0
Angle between R.O. and ✲ (from Angle Book) .. .. =	17	13	4·2
* ∴ Azimuth of R.O. from Elevated Pole .. .. .. =	126	39	16·2

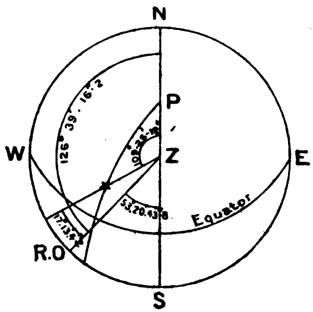


FIG. 92.

		°	′	″	
		360	0	0	
Magnetic Bearing of R.O.	N.	249	50	0	E.
	N.	110	10	0·0	W.
True Bearing or Azimuth of R.O.	N.	126	39	16·2	W.
Error of Compass		16	29	16·2	W.

NOTE.—When stars are used for Azimuth the Theodolite can be set on to the R.O. before dark, or failing this a distant light taken and the angle between this and the R.O. measured afterwards. The final Azimuth accepted should be the mean of a pair of E. and W. stars, and should never depend upon star taken only on one side of the Meridian

* Azimuth for Geodetic purposes should be measured from the South by West. It is best ascertained from the above data by consideration of a figure showing the relative positions of Star, Pole, and R.O. as above.

Sextant Observation for Azimuth and Error of Compass.

Whenever possible, azimuths should be observed with a theodolite, as the horizontal angle between the reference object (R. O.) and the sun or star is then read directly on the horizontal circle. When a theodolite is not available, the observation can be taken with a sextant, but it is more complicated, as the angle measured is the *oblique* angle between the sun or star and the object, and the horizontal angle has to be deduced from this. In the form here given this part of the computation is performed by Napier's Circular Part rules.

For the sun the observation consists of measuring the sun's altitude, then the angles between the object and the nearer and farther limbs of the sun, and lastly the sun's altitude again. Note the times of each contact. If the object has any altitude observe it, and note whether it is east or west of the sun. Half the sum of the times of the observed angular distances is the mean of times of the observation, and half the sum of the angles observed is the apparent angle; but if the farther limb only be observed, the apparent angle is found by subtracting the sun's semi-diameter; or if the nearer limb, by adding. From the observed altitudes of the sun the altitude at the time of the observed angle is found by simple proportion.

With time at place find Greenwich date, either by the error and rate of the watch, or with the longitude in time.

Take the declination from the 'Nautical Almanac' (if *App.* time is used, Page 1.; if *Mean* time, Page II.); correct this for the Greenwich date. From the observed altitude find the *True Alt.*

If the observed object has an altitude,

$$\text{Add together} \left\{ \begin{array}{l} \textit{Log sine of object's alt.,} \\ \textit{Log sine of } \odot\textit{'s app. alt.,} \\ \textit{Log cosec. of app. angle,} \end{array} \right\} \begin{array}{c} \text{rejecting 20 from} \\ \text{the index.} \end{array}$$

and take out the sum as a log sine: the result is the corrected angle.

If the observed object has no altitude, or if its altitude is very small, this step is neglected, and the apparent angle is used as the corrected angle.

Find the apparent alt. from the true alt. already found, from the observed angular distance find the apparent distance, and from the cos of the dist. from ⊙'s centre, subtract the cos of the apparent altitude;

the remainder will be the cos of difference of bearings. If the sun be *East* of the meridian, and the object more *East*, or the sun be *West*, and the object more *West*, *add* the difference of bearing thus found to the ☉'s true bearing. In any other case, take the difference between the sun's true bearing and the difference of bearings, and the result is the true bearing of the object.

When a star is used the R. O. must be a lamp, or some other illuminated object, and of course there is no semidiameter to consider.

Sextant Observation for Azimuth and Error of Compass.

July 15th, 1905, P.M. at Place, Angles and Altitudes taken with a Sextant. (ϕ) Latitude, 51° 24′ N. Longitude, 3′ 15″ E. Index Error − 2′ 10″. Time, 3h. 3m. 18s. Observed Altitude in Quicksilver, 87° 45′. Observed Angular Distance of an Object, East of the Sun, 109° 12′ 10″.

		H.	M.	S.
L.M.T.		3	3	18
Longitude in Time, E.	−		0	13
G.M.T.		3	3	5

		°	′	″
Observed Altitude in Quicksilver ☉		87	45	00
Index Error	−		2	10
	2)	87	42	50
Observed Altitude		43	51	25
Refraction (mean)	−		1	0·9
		43	50	24·1
Semidiameter	+		15	45·6
		44	6	9·7
Parallax	+			5·9
(h) True Altitude		44	6	15·6

		°	′	″
Observed Altitude ☉		43	51	25
Semidiameter	+		15	45·6
Apparent Altitude ☉		44	7	10·6

		°	′	″	
Declination (p. ii. N.A.)		21	36	12·9	N.
Correction by Hourly Difference for G.M.T.	−		1	10·8	
		21	35	2·1	N.
		90	00	00	
North Polar Distance	=	68	24	57·9	(p)

	°	′	″		
$s = \frac{h + \phi + p}{2} =$	81	57	36·7	Log sec =	0·854302
$s - p =$	13	32	38·8	Log sec =	0·012249
$s - \phi =$	30	33	36·7	Log sin =	9·706242
$s - h =$	37	51	21·1	Log sin =	9·787940
				2)	20·360733
				Log tan $\frac{A}{2}$ =	10·180366

		°	′	″	
$\frac{A}{2} =$		56	34	11	
			×	2	
A = True Azimuth of Sun	N.	113	8	22	W.
		180	0	0	
	S.	66	51	38	W.

		°	′	″			
Observed Angular Distance of Object from the near limb of the Sun, *corrected for Index Error*		109	10	00			
☉'s Semidiameter	+		15	45·6			
Distance from ☉'s centre	=	109	25	45·6	.. Cos	.. ..	9·521981
☉'s Apparent Altitude		44	7	10·6	.. Cos	.. ..	9·856057
Difference of Bearings	=	62	23	44	.. Cos	.. .. =	9·665924
		*180	00	00			
		117	36	16			

		°	′	″	
Magnetic Bearing of Object (R.O.) taken with Prismatic Compass	N.	145	30	0	E.
		180	0	0	
(*a*)	S.	34	30	0	E.

		°	′	″	
True Azimuth of Sun	S.	66	51	38	W.
Object E. of ☉		117	36	16	
True Bearing of Object..	S.	50	44	38	E.
(*a* Magnetic Bearing of Object	S.	34	30	0	E.
Error of Compass .. .. =		16	14	38	W.

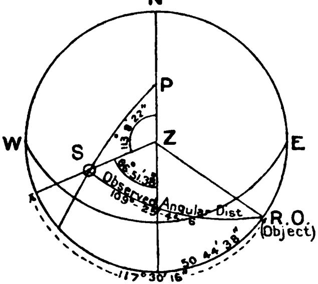


FIG. 93.

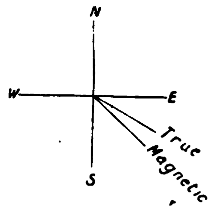


FIG. 94.

N.B.—When the True Azimuth is to the left of the magnetic, the variation is West; when True Azimuth is to the right, the variation is East.

* If the observed angular distance is greater than 90°, subtract this difference of bearings from 180°.

Another method of finding the error of the compass when only a sextant is available, which if not very accurate, is decidedly simple, is to observe a set of altitudes of the sun, and as soon after each altitude as possible, take the compass bearing of the sun, writing these down so that they come between the altitudes, thus:—

Times.	⊙ Altitudes in Art. Hor.	Compass Bearing of ⊙.
h. m. s.	° ′ ″	° ′ ″
9 38 40	93 22 0	
		137 45 0
9 41 15	94 2 0	
		138 30 0
9 43 43	94 42 0	
		139 15 0
9 46 13	95 20 0	

Then the means of the times and altitudes will correspond approximately to the mean of the compass bearings. From the altitudes compute the True Azimuth of the sun in the manner previously described (p. 258), and the difference between this and the mean of the compass bearings will be the error of the compass.

Azimuth by Circum-Polar Star at Elongation.

A circum-polar star useful for this observation is one with a polar distance of less than 10°. A star is at elongation when the angle at S in the triangle P Z S (Fig. 93) is a right angle.

The time of elongation (t) is computed from the formula $\cos t = \tan$ lat. tan polar dist.

Then the angle between the R. O. and the star is observed at this time.

The azimuth of the star can be computed for the same moment from the formula $\sin A = \sec$ lat. sin polar dist.

It is sufficient to take an observation on each face within a few minutes of the computed time of elongation. Only the times and horizontal angles need be recorded. Thus the observations would be:—Face right; R. O., star. Face left; star, R. O. With a quick observer these might be repeated.

The means of the angles between the R. O. and the star can then be taken, provided that in ordinary latitudes no time differs from that of elongation by five minutes either way. This gives a range of ten minutes for observing.

The angle A is then added to or subtracted from this observed angle to obtain the azimuth of the R. O. A rough diagram should be drawn.

The altitude of the star at elongation is given by, sin alt. = sin lat. sec polar dist.

The method is an easy one, both as regards observing and computing, and gives good results, provided the time limits are not exceeded.

The computation is so simple that no example is thought necessary.

The Azimuth of any distant point can of course be readily obtained when the transit theodolite is placed accurately in the plane of the meridian, by simply taking the difference between the meridian reading on the horizontal circle and that of the object. The theodolite may be placed in the meridian by either of the following methods:—

To Place a Theodolite in the True Meridian.

By Meridian Passage of the Pole Star.—Find the mean time of the meridian passage of the pole star in the manner shown on p. 217. Level the instrument, and if this be carefully done the line of collimation will move in a plane perpendicular to the horizon, and will pass through the zenith, then by making it also pass through the celestial pole, and clamping the horizontal plates when it is in that position, the movements of the telescope will be restricted to the plane of the meridian. This is done by turning the telescope on to the pole star, and covering it with the point of intersection of the telescope wires at the time (previously ascertained) of its upper or lower culmination, and then firmly clamping the horizontal plates. The meridian line should now be laid out to the north and south of the observer by sending a man with a lantern and a staff in both directions, and making him drive the staff into the ground at the spot where the observer sees the lantern in a central position on the cross wires of the telescope.

By High and Low Stars.—This method is accurate, and will be found convenient when the pole star cannot be observed. Having placed the instrument approximately in the meridian, choose two stars differing *considerably* in declination, and but *little* in right ascension. Note carefully the time that each star passes the central wire; take the difference of these times, to which apply the rate of the watch, due for the interval, and convert this into a sidereal interval by Table XVI., or by the

'Nautical Almanac' table of time equivalents. Take from the 'Nautical Almanac' the apparent right ascensions of the stars, and subtract the less from the greater. If this difference agrees exactly with the sidereal interval obtained by the watch, the telescope will move in the meridian, but when this is not the case, and the interval shown by the watch is less than the difference of the stars' right ascensions, the telescope must be moved to the *west;* if the contrary be the case the telescope must be moved to the *east.* This supposes the high star to have been observed first, but when the low star is the first to pass, the opposite will be the case. The operation must be repeated until the sidereal interval, computed from the watch times of transit, and the difference of the stars' right ascensions taken from the 'Nautical Almanac,' agree exactly; the telescope will then move in the plane of the meridian.

By Meridian Passage of any Star.—Any star may be used if the local time is accurately known, and the time of the star's meridian passage carefully computed (as shown, p. 217). The observation is precisely the same as for the pole star, but it would be well to take more than one star in order to correct any errors that may have been made in observation or computation. Though the results of such observations as these are susceptible of a great degree of precision, absolute accuracy must not be expected.

By Stars East and West of the Meridian.—If local time is not accurately known, the true meridian may be found in the following manner:—Carefully level the transit theodolite, and set the 360° division as nearly *true* north as possible by the attached magnetic needle, then clamp the lower plate, and unclamp the vernier plate; select any star at some considerable distance east of the meridian, and cover it with the intersection of the threads in the diaphragm, *clamp the vertical circle,* and take the reading on the horizontal plate; then, after the necessary interval, watch the star until it is again covered with the intersection of the threads in the diaphragm west of the meridian, take the reading, and then the theodolite will point just as far west of the meridian as it originally did to the east, and a point midway between these two horizontal readings will be in the true meridian. Care must be taken to keep the vertical circle and the lower plate clamped during the interval between these two observations. Having thus found the true meridian it can be marked as previously directed. Owing to the constant change in the sun's declination it is unsuited for finding the meridian by this method.

PART VI.

TABLES.

Explanation of the Tables.

Table I. and II.—These tables contain the corresponding divisions of Time and Arc.

Table III. *Mean Astronomical Refraction.*—The refraction is given for the barometer at 30 inches, and Fahrenheit's thermometer at 50°. The diff. to 10′ of alt. is inserted.

Example 1.—The refraction at 20° is 2′ 39″.

Example 2.—The refr. to the alt. 38° 35′ is 1′ 13·3″, deducting ·2, or 1′ 13·1″.

The tenths of seconds are omitted at altitudes below 35°, on account of the uncertainty at low altitudes.

To find the Refraction approximately.—The mean refraction is approximately proportional to the tangent of the zenith distance, and is 58·2″ at zenith distance 45°. It can be computed by the formula $r' = 58{\cdot}2'' \tan (z - 3\,r')$, where r' = mean refraction and z = zenith distance.

Table IV. *Correction of the Mean Refraction for the Height of the Thermometer.*—The table is entered with the alt. at the top, and the degree of Fahrenheit's therm. at the side. When the therm. is *below* 50° the correction is *added* to the mean refr.; when above 50°, it is *subtracted.*

Example.—Alt. 17° 10′, therm. 72°; the corr. is 8″, which, subtracted from the mean refr., 3′ 7″, gives the true refraction 2′ 59″.

To find the Correction, nearly.—Multiply the mean refraction in seconds by 2, and by the difference between the height of the therm. and 50°, and divide the product by 1000.

Example.—Alt. 5°, therm. 38°. The mean refr. 9′ 54″, or 594″, mult. by 2 and by 12, is 14256, and this divided by 1000 gives 14″.

Table V.—*Correction of the Mean Refraction for the Height of the Barometer.*—The correction is given to each tenth of an inch. The table is entered like Table IV. When the barom. is *above* 30 inches, the correction is to be *added;* when *below, subtracted.*

Example—Alt. 17° 10′, barom. 29·2 in.; the corr. is 5″, and true refr. 3′ 2″.

To find the Correction.—Multiply the mean refr. in seconds by the difference between the height of the barom. and 30 inches, and divide the product by 30.

Example (above).—3′ 7″, or 187″, mult. by ·8, and divid. by 30, gives 5″.

Table VI. *The Sun's Parallax in Altitude.*—This is given for convenience on some occasions, but not for extreme precision.

To compute the Sun's Parallax in Altitude.—To the log of the horizontal parallax in seconds, given on the opening page of the N. A. for the date, add the log cos of the apparent altitude, and the result is the log of the parallax in altitude in seconds.

Table VII. *Parallax in Altitude of a Planet.*—The table is entered with the planet's horizontal parallax at the top and its altitude at the side, and the corresponding seconds taken out.

Table VIII. *For computing the Reduction to the Meridian in Seconds.* This table gives the values of $\frac{2 \sin^2 \text{half-hour angle}}{\sin 1''}$, and is used in finding the latitude by altitudes of the sun or stars when they are near the meridian.

The seconds forming the reduction are taken out to the min. and sec. of the hour-angle.

To compute a Term.—To the const. 5·615455 add the log sine square of the hour-angle; the sum is the log of the number of seconds. Although this table extends to an hour-angle of 30^m, good results can only be obtained when the hour-angle is *much less* than this, and it should never be greater than 15^m.

Table IX. This table gives the lengths in English statute miles of 15′ of latitude, 15′ of longitude, and the diagonal line, between the parallels, from 0° to 70° latitude, the latter being computed from the formula: $q = \sqrt{m^2 + p\,n}$.

These lengths are used in constructing the projection for plane-table sheets, an example of which, and the method of using the table, is given on p. 90.

Tables X. and XI. These tables have been computed by Dr. Francis Galton from Tables XXVI. and II. of the hypsometric series in Guyot's collection. They will give much facility to the traveller both in calculating altitudes, and in checking the index error of the aneroid, by means of the boiling-point thermometer. It did not seem worth while to correct the figures thence obtained for the slight excess of temperature, viz.: 0°·015 Fahrenheit of the French boiling-point over that of the English. It is too small to be sensible in ordinary instruments, and it becomes totally unimportant in determining *differences* of level, or *changes* in the index error of an aneroid. An example of the method of using the tables for the determination of heights is given on p. 192.

Table XII. This table, consisting of five parts, is for the computation of heights by mercurial barometer or aneroid, and has been arranged by Dr. Francis Galton from the tables computed by Loomis, given in Guyot's collection. The method of using the table is shown by the example on p. 191.

Tables XIII., XIV. and XV. These geodetic tables, based upon those given in the Auxiliary Tables of the Survey of India, but extended in latitude to 60°, are taken from tables in the Text Book of Topographical and Geographical Surveying. They are used in geodetic computations of the differences of latitude, longitude and azimuths. The manner of taking out the quantities is simple, and all that has to be done is to enter the tables with the known or middle latitude at the side and take out the numbers corresponding. Examples of computations made with these constants and numbers will be found on pp. 108–123.

Table XVI. *Acceleration.*—This is the change of the sun's mean Right Ascension in a mean solar day. It is employed in reducing the sidereal time at mean noon to the Green. date, and in converting mean time into sidereal time.

The Acceleration is itself a portion of sidereal time.

Table XVII. *Retardation.*—This is the change of the sun's mean Right Ascension in a sidereal day. It is employed in converting sidereal time into mean time.

The retardation is itself a portion of mean time.

Table XVIII. *Diminution of the Moon's Horizontal Parallax for the Spheroidal Figure of the Earth.*—The table is entered with the horizontal parallax at the top and the latitude at the side; the seconds corresponding are to be *subtracted* from the equatorial hor. par.

Table XIX. *Augmentation of the Moon's Semidiameter.*—The table is entered with the moon's semidiameter at the top and her altitude at the side; the seconds corresponding are the excess by which her apparent semidiameter at her actual altitude exceeds that at which it would appear if seen from the centre of the earth.

Table XX. *Reduction of the Latitude.*—This is the difference between the latitude as actually found by any astronomical observation and what it would be if the earth were a sphere, which latter is called the *geocentric* latitude.

To reduce the lat. by observation to the geocentric latitude, *subtract* the reduction of latitude.

This quantity, which is also called the *angle of the vertical*, is 0 at the equator and at the pole, and is greatest in lat. 45°.

The compression assumed is $\frac{1}{293 \cdot 47}$; that is, the polar radius is supposed to be shorter than the equatorial radius by $\frac{1}{293 \cdot 47}$ of the latter. This is Clarke's 1866 value.

Table XXI. exhibits half the time that a celestial body continues above the horizon when the latitude and declination are the same name; or below when they are contrary names, and affords the means for computing the rising and setting of the sun, moon and stars, and the length of the night or day.

To find the time of the sun's rising or setting, enter the table with the latitude and declination, and the tabular value will show the apparent time of the sun's setting when the latitude and declination are the same name, or of its rising when the latitude and declination are of contrary names, and this, subtracted from 12 hours, will give the apparent time of the sun's rising in the former case, and of its setting in the latter.

Double the time of rising will give the length of the night.

Double the time of setting will give the length of the day.

Example.—Required the (apparent) time of the sun's rising and setting, and the length of the day and night in lat. 46° N., and the declination 18° N.

Tabular value answering to lat. 46° and decl. 18° is 7 h. 19 m. Hence in lat. 46° N., decl. 18° N., time of sunset is 7 h. 19 m., and that of sunrise 12 h. − 7 h. 19 m. = 4 h. 41 m.

The same is true for lat. 46° S., decl. 18° S.

Conversely, both for lat. 46° N., decl. 18° S., and for lat. 46° S., decl. 18° N., the time of sunrise is 7 h. 19 m., and that of sunset is 4 h. 41 m.

In the first pair of cases the length of the day is 7 h. 19 m. × 2 = 14 h. 38 m., and that of the night is 4 h. 41 m. × 2 = 9 h. 22 m.; and in the second pair, conversely, the length of the night is 14 h. 38 m., and that of the day 9 h. 22 m.

Example.—At what time (apparent) does the star *a Ophiuchi* rise and set on May 12th, in lat. 30 S.?

	H.	M.
Star's R.A.	17	29
Sun's R.A.	3	15
Star's approximate meridian passage	14	14
Time answering in table to 30° S. lat., and star's declination 12° 39′ N. = 6 h. 30 m. which, subtracted from 12, gives 5 h. 30 m...	5	30
Remainder = time of star's rising	8	44
Sum = time of star's setting	19	44 P.M.
or	7	44 A.M.

Table XXII., giving the distance of the horizon as seen over water from different heights above it, will be found very useful both in checking exaggerated estimates of the width of lakes whose opposite shores are invisible, and also as a rough means of judging the distance of objects seen across water.

Table XXIII. gives the number of geographical miles, or minutes of the equator, contained in a degree of longitude under each parallel of latitude.

Table XXIV. is for converting statute into geographical miles.

Table XXV. is for converting geographical into statute miles.

Table XXVI. contains a comparison of Fahrenheit, Reaumur, and Centigrade thermometer scales.

Table XXVII. contains a comparison of English and French barometer scales to hundredths of an inch.

Table XXVIII. contains a comparison of mètres and English feet.

Table XXIX. contains a comparison of kilomètres and English statute miles.

Table XXX. contains a comparison of Russian versts and English statute miles.

Table XXXI. contains foreign moneys, with equivalents in British currency.

Table XXXII. This table contains the angles subtended by a 10-foot rod, at distances from 50 to 1500 feet. The angles are given for every foot from 50 to 200 feet, for every two feet from 200 to 402 feet, and for every yard from 402 to 1500 feet. To use the table, search column for the angle measured, and opposite to this will be found the distance in feet. In that part of the table where the distances are only given for every second or third foot, intermediate distances can be found by interpolation.

Table XXXIII. contains useful constants.

Table XXXIV. *For Converting Metrical Weights and Measures.*—An explanation of its use is given at the foot of the table, with examples.

Table XXXV. *Logarithms of Numbers.*—The table contains the logs of numbers from 1 to 9999, to six places, with differences and proportional parts.

The diff. D. is the mean of the diffs. between each log and the succeeding one in the same line; and is near enough for most cases.

I. *Direct process;* to find the logarithm of a given number.

1. To find the logarithm to any number consisting of two or three figures. Look for the number at the side, and take out the log against it. Thus, the log of 717 is 855519.*

2. To find the logarithm of a number consisting of four figures. Look for the three first figures at the side, and the fourth at the top; thus, the log of 7176 is 855882.

3. To find the logarithm of a number consisting of more than four figures. Find the log of the first four figures; find the diff. D. in the

* This, however, is only part of the complete logarithm, as adapted for purposes of computation. and requires the characteristic.

lower part of the table, in column D, and against it, under the 5th figure (or 6th, if required), are the parts, which add.

Example 1.—(*Five* figs.) Find the log of 26574.

2657 log.	424392	D. 164
Against D. 164, under 4	66	
Loo req.	424458	

Example 2.—(*Six* figs.) Find the log of 265748.

2567 log	424392	D. 164
4 (parts 66)	66	
* 8 (parts 131 ÷ 10)	13	
Log req.	424471	

The arithmetical complement of a logarithm (Ar-co-log) is found by taking the logarithm from 10·000000, thus the Ar-co-log of 2·564782 is 7·435218.

II. *Inverse process;* to find the number corresponding to a given log.

1. When the natural number is not required to consist of more than four figures, it is taken out at once.

Example.—Given the log 645820, required the natural number.

The nearest log in the table is 645815; the figures at the side are 442, annexing to which that at the top, or 4, gives 4424, the NUMBER required.

To place the decimal point. Add 1 to the given index of the log, and mark off to the left this number of figures; these will be whole numbers; the rest, if any, will be decimals.

2. When the number is to consist of *five* figures. Take out the next less log to the one given, and note down the four figures of the corresponding number. Note the diff. D.

Subtract this next less log from the given one, and look for the remainder among the parts standing against D, in the lower part of the table; note the figure at the top under which the remainder is found, and add it to the four taken out.

3. When the number is to consist of *six* figures, the more direct and accurate method is to take the diff. between the given log and the next less in the table, annex 2 ciphers, and divide by the diff. between the

* Observe to set down the parts correctly, carrying those for the 6th figure one place to the right of the parts above them, as a mistake frequently occurs here.

next less and the next greater; the quotient is the number of figures to be annexed to the natural number, answering to the *next less* log.

Place the decimal point as previously directed.

Example 1.—(*Five* figs.) Find the No. to the log 424471.

Given	424471	
Next less (2657)	424392	D. 164
Rem.	79	
5th fig. 4, next less	66	
NUMB. req.	26574	

Example 2—(*Six* figs.) Find the number to the log 424471.

Given log	424471	
Next less (2657)	424392	79
Next greater	424555	163

Then 7900 ÷ by 163, gives 48, and the number req. is 265748

Table XXXVI. Gives Natural Sines, Cosines, Tangents, Cotangents, Secants, and Cosecants for every degree from 0° to 90°.

Table XXXVII. *Logarithmic Sines, Cosines, Tangents, Cotangents, Secants, and Cosecants.*—The table contains the terms to half-minutes, and to six places.

The second column and the last but one contain a time scale, corresponding to the upper and lower degree; thus 73° 33′ 30″ corresponds to 4h. 54m. 14s. This scale is very convenient for converting arc and time, but it is introduced to suit those computations in which the time itself is an argument.

The parts for each second are given beyond 9°; from 4° to 9°, to each 10″; but under 4° the variation is too rapid for their insertion, and the mean differences are given in the column marked D.* The parts are true for the *middle* term of the argument; thus, the parts from 20° 30′ to 20° 45′ are true for 20° 37½′, and approximate for the rest, but the inaccuracy in the extreme case corresponds only to ⅓ of 1″.

It is, of course, the more correct way to take the parts with reference to the *nearest* term, and to apply them accordingly; thus, to find the sine of 9° 40′ 28″, find it for 9° 40′ 30″, and *subtract* the parts for 2″.

For greater accuracy proceed by proportion.

Direct process. When the given angle is less than 45°, its log sine, etc.

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* The difference D., in the early portion (inserted merely for uniformity), is not that of two consecutive terms, but corresponds to *half* the tabular interval on *both* sides of a term. This is done to avoid breaking the continuity of the horizontal lines, which must occur when actual differences are exhibited, and is teasing to the eye.

are taken from the top; when greater than 45°, from the bottom; thus, the log sine of 28° 17′ is 9·675624; the log sine of 84° 3′ is 9·997654. In like manner, the log sine 9·452060 corresponds to the arc 16° 27′, the cotangent 9·47714 to the arc 73° 18′.

The log sine of an angle is the log cosine of the complement of the angle to 90°, whether in excess or defect; so, likewise, the log cosine is the log sine of the complement; and the like holds of the tangent and cotangent, secant and cosecant.

When the given angle exceeds 90°, find the log sine, tangent, or secant, for the supplement to 180°. But it is generally easier to find the log *co*-sine, *co*-tangent, and *co*-secant, for the *excess* above 90°.

Example 1.—The log sine of 127° 50′ is the log sine of 52° 10′, or the log cos of 37° 50′, which is 9·897516.

Example 2.—The log cos of 163° 49′ is the log cos of 16° 11′, or the log sine of 73° 49′, which is 9·982441.

Example 3.—The log cosec of 97° 4′ is the log cosec of 82° 56′, or the log sec of 7° 4′, which is 0·003312.

In like manner to find the log *co*-sine, *co*-tangent, or *co*-secant, of an arc above 90°, take out the log sine, tangent, or secant, of the excess above 90°.

To find the log sine, etc., of an arc given to seconds. Find the log sine (or cosine, etc.) for the next less minute or half-minute; take out the parts for the seconds, or for the excess above 30″.

For the sine, tangent, and secant, *add* the parts.

For the *co*-sine, *co*-tangent, and *co*-secant, *subtract* them.

Example 1.—Find the log sine of 53° 25′ 13″.

53° 25′ 0″ sine	9·904711
13 parts	+ 20
Log sine req.	9·904731

Example 2.—Find the log tan of 11° 19′ 54″.

11° 19′ 30″ tan	9·301624
24 parts	+ 262
Log tan req.	9·301886

Example 3.—Find the log sec of 38° 42′ 46″.

38° 42′ 30″	0·107716
16 parts	+ 27
Log sec req.	0·107743

Example 4.—Find the log cosine of 72° 10′ 45″.

°	′	″		
72	10	30	.. ..	9·485879
		15 parts	.. ..	− 98
Log cos req.			.. ..	9·485781

Example 5.—Find the log cotang of 84° 3′ 22″.

°	′	″		
84	3	0 cot	.. ..	9·017959
		20 parts 408 / 2 41	.. ..	− 449
Log cotang req.			.. ..	9·017510

Example 6.—Find the log cosec of 68° 14′ 11″.

°	′	″		
68	14	0 cosec	.. ..	0·032124
		11 parts	.. ..	− 9
Log cosec req.			.. ..	0·032115

In working to five places, the last figure of the parts must be dropped, the remainder being increased by 1 when the figure dropped exceeds 5.

In working to 1 sec. of time, the parts for 15″ are to be employed. In the earlier part of the table, *half* the D. for 30″ may be conveniently employed.

It is convenient in dealing with parts of contrary application, to mark those *additive* with +, and *subtractive* with −; to sum each kind separately; and to take the diff. of the two sums, marking it with the sign of the greater.

Inverse process. To find the arc, to seconds, corresponding to a given log sine, etc.

For the sine, tangent, or secant, take out the next *less;* for the *co*-sine, *co*-tangent, or *co*-secant, take out the next *greater;* and note the degree and minute, or half-minute, of the quantity thus taken out.

Take the diff. between this quantity and the given one; find the remainder in the column of Parts; take out the seconds corresponding, and *add* them to the arc noted.

Example 1.—Find the arc to the log sine 9·202470.

	°	′	″		
				Given	9·202470
	9	10	0	Next less	9·202234
			18	Rem.	236
Arc req.	9	10	18		

Example 2.—Find the arc to the log cosine 9 897796.

	°	′	″		
				Given	9·897796
	37	47	0	Next greater..	9·897810
			8	Rem.	
Arc req.	37	47	8		

When the parts are not given for seconds beyond 10 (as for the log sine and tang from 4° to 8°), if the remainder exceeds the parts given, take away the parts for 10″ or 20″; add 10″ or 20″ accordingly, and also the seconds corresponding to this last remainder.

Example 1.—Find the arc to the log tangent 9·127945.

	°	′	″		
				Given	9·127945
	7	38	30	Next less	9·127651
					294
			10	Parts	160
			8	Rem.	134
Arc req.	7	38	48		

Example 2.—Find the arc to the log cosec 10·881005.

	°	′	″		
				Given	10·881005
	7	33	0	Next greater	10·881433
					428
			20	Parts	318
			7	Rem.	110
Arc req.	7	33	27		

When greater precision than that afforded by the parts is required, the log sine, etc., or the arc may be found by means of the proportional part of the diff. between two terms, or for 30″.

The log cosec is the arith. compl. of the log sine.

The log cotan is the ar. co. of the log tan.

The log sec is the ar. co. of the log cosine.

The log tan is the sum of the log sine and log secant; thus all may be obtained from the log sine.

TABLE I.

ARC.					
°	H. M.	′	M. S.	″	S.
0	0 0	0	0 0	0	0·00
1	0 4	1	0 4	1	0·07
2	0 8	2	0 8	2	0·13
3	0 12	3	0 12	3	0·20
4	0 16	4	0 16	4	0·27
5	0 20	5	0 20	5	0·33
6	0 24	6	0 24	6	0·40
7	0 28	7	0 28	7	0·47
8	0 32	8	0 32	8	0·53
9	0 36	9	0 36	9	0·60
10	0 40	10	0 40	10	0·67
11	0 44	11	0 44	11	0·73
12	0 48	12	0 48	12	0·80
13	0 52	13	0 52	13	0·87
14	0 56	14	0 56	14	0·93
15	1 0	15	1 0	15	1·00
16	1 4	16	1 4	16	1·07
17	1 8	17	1 8	17	1·13
18	1 12	18	1 12	18	1·20
19	1 16	19	1 16	19	1·27
20	1 20	20	1 20	20	1·33
30	2 0	21	1 24	21	1·40
40	2 40	22	1 28	22	1·47
50	3 20	23	1 32	23	1·53
60	4 0	24	1 36	24	1·60
70	4 40	25	1 40	25	1·67
80	5 20	26	1 44	26	1·73
90	6 0	27	1 48	27	1·80
100	6 40	28	1 52	28	1·87
110	7 20	29	1 56	29	1·93
120	8 0	30	2 0	30	2·00
130	8 40	31	2 4	31	2·07
140	9 20	32	2 8	32	2·13
150	10 0	33	2 12	33	2·20
160	10 40	34	2 16	34	2·27
170	11 20	35	2 20	35	2·33
180	12 0	36	2 24	36	2·40
		37	2 28	37	2·47
		38	2 32	38	2·53
		39	2 36	39	2·60
		40	2 40	40	2·67
		41	2 44	41	2·73
		42	2 48	42	2·80
		43	2 52	43	2·87
		44	2 56	44	2·93
		45	3 0	45	3·00
		46	3 4	46	3·07
		47	3 8	47	3·13
		48	3 12	48	3·20
		49	3 16	49	3·27
		50	3 20	50	3·33
		51	3 24	51	3·40
		52	3 28	52	3·47
		53	3 32	53	3·53
		54	3 36	54	3·60
		55	3 40	55	3·67
		56	3 44	56	3·73
		57	3 48	57	3·80
		58	3 52	58	3·87
		59	3 56	59	3·93

TABLE II.

TIME.							
H.	°	M.	° ′	S.	′ ″	10ths	″
0	0	0	0 0	0	0 0	0·0	0·0
1	15	1	0 15	1	0 15	0·1	1·5
2	30	2	0 30	2	0 30	0·2	3·0
3	45	3	0 45	3	0 45	0·3	4·5
4	60	4	1 0	4	1 0	0·4	6·0
5	75	5	1 15	5	1 15	0·5	7·5
6	90	6	1 30	6	1 30	0·6	9·0
7	105	7	1 45	7	1 45	0·7	10·5
8	120	8	2 0	8	2 0	0·8	12·0
9	135	9	2 15	9	2 15	0·9	13·5
10	150	10	2 30	10	2 30	1·0	15·0
11	165	11	2 45	11	2 45		
12	180	12	3 0	12	3 0		
13	195	13	3 15	13	3 15		
14	210	14	3 30	14	3 30		
15	225	15	3 45	15	3 45		
16	240	16	4 0	16	4 0		
17	255	17	4 15	17	4 15		
18	270	18	4 30	18	4 30		
19	285	19	4 45	19	4 45		
20	300	20	5 0	20	5 0		
21	315	21	5 15	21	5 15		
22	330	22	5 30	22	5 30		
23	345	23	5 45	23	5 45		
24	360	24	6 0	24	6 0		
		25	6 15	25	6 15		
		26	6 30	26	6 30		
		27	6 45	27	6 45		
		28	7 0	28	7 0		
		29	7 15	29	7 15		
		30	7 30	30	7 30		
		31	7 45	31	7 45		
		32	8 0	32	8 0		
		33	8 15	33	8 15		
		34	8 30	34	8 30		
		35	8 45	35	8 45		
		36	9 0	36	9 0		
		37	9 15	37	9 15		
		38	9 30	38	9 30		
		39	9 45	39	9 45		
		40	10 0	40	10 0		
		41	10 15	41	10 15		
		42	10 30	42	10 30		
		43	10 45	43	10 45		
		44	11 0	44	11 0		
		45	11 15	45	11 15		
		46	11 30	46	11 30		
		47	11 45	47	11 45		
		48	12 0	48	12 0		
		49	12 15	49	12 15		
		50	12 30	50	12 30		
		51	12 45	51	12 45		
		52	13 0	52	13 0		
		53	13 15	53	13 15		
		54	13 30	54	13 30		
		55	13 45	55	13 45		
		56	14 0	56	14 0		
		57	14 15	57	14 15		
		58	14 30	58	14 30		
		59	14 45	59	14 45		

TABLE III.—Mean Astronomical Refraction.

Barometer, 30 inches; Fahrenheit's Thermometer, 50°.

App. Alt.	Refraction.	D. to 10′.	App. Alt.	Refraction.	D. to 10′.	App. Alt.	Refraction.	D to 10′.	App. Alt.	Refraction.
° ′	′ ″	″	° ′	′ ″	″	° ′	′ ″	″	° ′	′ ″
0 0	34 17	122	6 10	8 18	12	12 50	4 11	3·2	35 0	1 23·2
0 10	32 15	112	6 15	8 12	12	13 0	4 8	3·1	35 30	1 21·7
0 20	30 23	102	6 20	8 6	11	13 10	4 5	3·1	36 0	1 20·2
0 30	28 41	94	6 25	8 1	11	13 20	4 2	3·0	36 30	1 18·8
0 40	27 7	86	6 30	7 56	11	13 30	3 59	3·0	37 0	1 17·4
0 50	25 41	78	6 35	7 50	11	13 40	3 56	2·9	37 30	1 16·0
1 0	24 22	73	6 40	7 45	10	13 50	3 53	2·9	38 0	1 14·6
1 10	23 9	67	6 45	7 40	10	14 0	3 50	2·8	38 30	1 13·3
1 20	22 2	62	6 50	7 35	10	14 10	3 47	2·7	39 0	1 12·0
1 30	21 0	58	6 55	7 30	10	14 20	3 45	2·6	39 30	1 10·7
1 40	20 2	53	7 0	7 25	9	14 30	3 42	2·5	40 0	1 9·5
1 50	19 9	49	7 5	7 20	9	14 40	3 40	2·5	41 0	1 7·1
2 0	18 20	46	7 10	7 16	9	14 50	3 37	2·4	42 0	1 4·8
2 10	17 34	44	7 15	7 11	9	15 0	3 35	2·4	43 0	1 2·6
2 15	17 12	42	7 20	7 7	9	15 10	3 32	2·3	44 0	1 0·4
2 20	16 51	40	7 25	7 3	9	15 20	3 30	2·2	45 0	0 58·4
2 25	16 31	39	7 30	6 59	9	15 30	3 28	2·2	46 0	0 56·3
2 30	16 11	38	7 35	6 54	9	15 40	3 25	2·1	47 0	0 54·4
2 35	15 52	37	7 40	6 50	8	15 50	3 23	2·1	48 0	0 52·6
2 40	15 34	36	7 45	6 46	8	16 0	3 21	2·1	49 0	0 50·7
2 45	15 16	35	7 50	6 42	8	16 10	3 19	2·1	50 0	0 49·0
2 50	14 59	34	7 55	6 38	8	16 20	3 17	2·1	51 0	0 47·3
2 55	14 42	33	8 0	6 35	8	16 30	3 15	2·0	52 0	0 45·6
3 0	14 26	32	8 5	6 31	7	16 40	3 13	2·0	53 0	0 44·0
3 5	14 10	31	8 10	6 27	7	16 50	3 11	2·0	54 0	0 42·4
3 10	13 55	30	8 15	6 23	7	17 0	3 9	1·9	55 0	0 40·9
3 15	13 41	29	8 20	6 20	7	17 30	3 3	1·9	56 0	0 39·4
3 20	13 27	28	8 25	6 16	7	18 0	2 58	1·8	57 0	0 37·9
3 25	13 13	27	8 30	6 13	7	18 30	2 53	1·7	58 0	0 36·5
3 30	13 0	26	8 35	6 9	7	19 0	2 48	1·6	59 0	0 35·1
3 35	12 47	25	8 40	6 6	6	19 30	2 44	1·5	60 0	0 33·7
3 40	12 34	25	8 45	6 3	6	20 0	2 39	1·4	61 0	0 32·4
3 45	12 22	24	8 50	6 0	6	20 30	2 35	1·3	62 0	0 31·0
3 50	12 10	24	8 55	5 57	6	21 0	2 31	1·2	63 0	0 29·8
3 55	11 58	23	9 0	5 54	6	21 30	2 27	1·2	64 0	0 28·5
4 0	11 47	22	9 5	5 51	6	22 0	2 24	1·1	65 0	0 27·2
4 5	11 36	21	9 10	5 48	6	22 30	2 20	1·1	66 0	0 26·0
4 10	11 26	21	9 15	5 45	6	23 0	2 17	1·0	67 0	0 24·8
4 15	11 15	20	9 20	5 42	6	23 30	2 13	1·0	68 0	0 23·6
4 20	11 5	20	9 25	5 39	6	24 0	2 10	1·0	69 0	0 22·4
4 25	10 55	19	9 30	5 36	5	24 30	2 7	0·9	70 0	0 21·3
4 30	10 46	19	9 35	5 33	5	25 0	2 5	0·9	71 0	0 20·1
4 35	10 37	18	9 40	5 31	5	25 30	2 2	0·9	72 0	0 19·0
4 40	10 28	18	9 50	5 25	5	26 0	1 59	0·9	73 0	0 17·9
4 45	10 19	18	10 0	5 20	5	26 30	1 56	0·9	74 0	0 16·7
4 50	10 10	17	10 10	5 15	5	27 0	1 54	0·8	75 0	0 15·7
4 55	10 2	16	10 20	5 10	5	27 30	1 51	0·8	76 0	0 14·6
5 0	9 54	16	10 30	5 6	5	28 0	1 49	0·8	77 0	0 13·5
5 5	9 46	16	10 40	5 1	5	28 30	1 47	0·7	78 0	0 12·4
5 10	9 38	15	10 50	4 56	4	29 0	1 45	0·7	79 0	0 11·3
5 15	9 30	15	11 0	4 52	4	29 30	1 43	0·7	80 0	0 10·3
5 20	9 23	15	11 10	4 48	4	30 0	1 41	0·7	81 0	0 9·2
5 25	9 16	14	11 20	4 44	4	30 30	1 39	0·6	82 0	0 8·2
5 30	9 9	14	11 30	4 40	4	31 0	1 37	0·6	83 0	0 7·2
5 35	9 2	14	11 40	4 36	4	31 30	1 35	0·6	84 0	0 6·1
5 40	8 55	13	11 50	4 32	4	32 0	1 33	0·6	85 0	0 5·1
5 45	8 48	13	12 0	4 28	4	32 30	1 31	0·6	86 0	0 4·1
5 50	8 42	13	12 10	4 25	4	33 0	1 30	0·6	87 0	0 3·1
5 55	8 36	12	12 20	4 21	4	33 30	1 28	0·5	88 0	0 2·0
6 0	8 30	12	12 30	4 18	4	34 0	1 26	0·5	89 0	0 1·0
6 5	8 24		12 40	4 14		34 30	1 25		90 0	0 0

TABLE IV.—Correction of the Mean Refraction for the Height of the Thermometer.

Therm.	Altitudes.																	
	4°	5°	5½°	6°	6½°	7°	7½°	8°	9°	10°	12°	15°	20°	30°	40°	50°	70°	90°
°	add ″	add ″	add ″	add ″	add ″	add ″	add ″	add ″	add ″	add ″	add ″	add ″	add ″	add ″	add ″	add ″	add ″	
0	69	61	57	54	51	48	46	43	39	36	30	25	18	12	8·1	5·7	2·5	0
2	66	58	55	51	48	46	43	41	37	34	29	23	18	11	7·7	5·4	2·4	0
4	63	56	52	49	46	44	41	39	36	32	28	22	17	11	7·4	5·2	2·3	0
6	60	53	50	47	44	42	39	37	34	31	26	21	16	10	7·0	4·9	2·1	0
8	57	50	47	44	42	40	37	36	32	29	25	20	15	10	6·7	4·7	2·0	0
10	55	48	45	42	40	37	35	34	31	28	24	19	14	9	6·3	4·4	1·9	0
12	51	45	42	40	37	35	34	32	29	26	22	18	14	9	6·0	4·2	1·8	0
14	48	42	40	37	35	33	32	30	27	25	21	17	13	8	5·6	4·0	1·7	0
16	44	40	37	35	33	31	30	28	26	23	20	16	12	8	5·3	3·7	1·6	0
18	42	37	35	33	31	29	28	26	24	22	19	15	11	7	5·0	3·5	1·5	0
20	39	35	33	31	29	28	26	25	22	20	17	14	11	7	4·6	3·3	1·4	0
22	36	32	30	29	27	25	24	23	21	19	16	13	10	6	4·3	3·0	1·3	0
24	33	30	27	26	25	24	22	21	19	17	15	12	9	6	4·0	2·8	1·2	0
26	30	27	26	24	23	22	20	19	18	16	14	11	8	5	3·7	2·6	1·1	0
28	28	25	23	22	21	20	19	18	16	15	12	10	8	5	3·3	2·4	1·0	0
30	26	23	21	20	19	18	17	16	15	13	11	9	7	4	3·0	2·1	0·9	0
32	22	20	19	18	17	16	15	14	13	12	10	8	6	4	2·7	1·9	0·8	0
34	21	18	17	16	15	14	13	13	12	10	9	7	5	3	2·4	1·7	0·7	0
36	18	16	15	14	13	12	12	11	10	9	8	6	5	3	2·1	1·5	0·6	0
38	15	13	12	12	11	10	10	9	9	8	7	5	4	3	1·8	1·3	0·5	0
40	13	11	10	10	9	9	8	8	7	6	5	4	3	2	1·5	1·0	0·4	0
42	10	9	8	8	7	7	7	6	6	5	4	3	3	2	1·2	0·8	0·4	0
44	7	6	6	6	5	5	5	5	5	4	3	3	2	1	0·9	0·6	0·3	0
46	5	4	4	4	4	3	3	3	3	2	2	2	1	1	0·6	0·4	0·2	0
48	2	2	2	2	2	2	2	2	1	1	1	1	1	0	0·3	0·2	0·1	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	sub.	sub.	sub.	sub.	sub.	sub.	sub.	sub.	sub.	sub.	sub.	sub.	sub.	sub.	sub.	sub.	sub.	
52	2	2	2	2	1	1	1	1	1	1	1	1	1	0	0·3	0·2	0·1	0
54	4	4	4	4	3	3	3	3	3	2	2	2	1	1	0·6	0·4	0·2	0
56	7	6	6	6	5	5	5	5	4	4	3	3	2	1	0·9	0·6	0·3	0
58	9	8	8	7	7	7	6	6	5	5	4	3	3	2	1·1	0·8	0·3	0
60	11	10	10	9	9	8	8	8	7	6	5	4	3	2	1·4	1·0	0·4	0
62	14	13	12	11	10	10	9	9	8	7	6	5	4	2	1·7	1·2	0·5	0
64	17	15	14	13	12	12	11	10	9	9	7	6	4	3	2·0	1·4	0·6	0
66	19	17	16	15	14	13	12	12	11	10	8	7	5	3	2·2	1·6	0·7	0
68	21	19	18	16	16	15	14	13	12	11	9	8	6	4	2·5	1·8	0·8	0
70	23	21	19	18	17	16	15	15	13	12	10	8	6	4	2·8	2·0	0·8	0
72	25	22	21	20	19	18	17	16	15	13	11	9	7	4	3·0	2·1	0·9	0
74	27	24	23	22	21	19	18	17	16	14	12	10	8	5	3·3	2·3	1·0	0
76	29	26	25	23	22	21	20	19	17	16	13	11	8	5	3·6	2·5	1·1	0
78	31	28	27	25	24	22	21	20	18	17	14	12	9	6	3·8	2·7	1·2	0
80	33	30	28	27	25	24	23	22	20	18	15	12	9	6	4·1	2·9	1·3	0
82	36	32	30	28	27	25	24	23	21	19	16	13	10	6	4·3	3·1	1·3	0
84	38	34	32	30	28	27	26	24	22	20	17	14	10	7	4·6	3·2	1·4	0
86	40	36	34	32	30	28	27	26	23	21	18	15	11	7	4·9	3·4	1·5	0
88	43	38	35	33	31	30	28	27	24	22	19	15	12	7	5·1	3·6	1·6	0
90	45	39	37	35	33	31	30	28	26	23	20	16	12	8	5·3	3·8	1·6	0
92	47	41	39	36	35	33	31	29	27	24	21	17	13	8	5·6	3·9	1·7	0
94	49	43	40	38	36	34	32	31	28	26	22	18	13	8	5·8	4·1	1·8	0
96	51	45	42	40	37	37	34	32	29	27	23	18	14	9	6·1	4·3	1·9	0
98	53	46	44	41	39	37	35	33	30	28	23	19	14	9	6·3	4·5	1·9	0
100	55	48	45	43	40	38	[illegible]	35	31	29	24	20	15	9	6·5	4·6	2·0	0

TABLE V.

Correction of the Mean Refraction for the Height of the Barometer.

Bar.	Altitudes.																		Bar.
	4°	5°	5½°	6°	6½°	7°	7½°	8°	9°	10°	12°	15°	20°	30°	40°	50°	70°	90°	
sub.	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″		*add*
27·5	60	50	46	42	40	37	35	33	29	27	22	18	13	8	5·8	4·0	1·8	0	
27·6	57	48	44	41	38	36	34	32	28	26	21	17	13	8	5·5	3·8	1·7	0	
27·7	54	46	42	39	37	34	32	30	27	25	20	17	12	8	5·3	3·7	1·6	0	
27·8	51	44	40	37	35	33	31	29	26	24	20	16	12	7	5·1	3·5	1·5	0	
27·9	48	42	38	36	33	31	29	28	25	22	19	15	11	7	4·8	3·3	1·5	0	
28·0	46	40	37	34	32	30	28	26	24	21	18	14	11	7	4·6	3·2	1·4	0	
28·1	44	38	35	32	30	28	27	25	22	20	18	14	10	6	4·4	3·0	1·3	0	
28·2	41	36	33	31	29	27	25	24	21	19	17	13	10	6	4·1	2·9	1·3	0	
28·3	39	34	31	29	27	25	24	22	20	18	16	12	9	6	3·9	2·7	1·2	0	
28·4	37	32	29	27	25	24	22	21	19	17	15	12	8	5	3·7	2·6	1·1	0	
28·5	35	30	27	25	24	22	21	20	18	16	14	11	8	5	3·4	2·4	1·0	0	31·5
28·6	32	28	26	24	22	21	20	18	17	15	13	10	7	5	3·2	2·2	1·0	0	31·4
28·7	30	26	24	22	21	19	18	17	15	14	12	9	7	4	3·0	1·9	0·9	0	31·3
28·8	27	24	22	20	19	18	17	16	14	13	11	9	6	4	2·8	1·8	0·8	0	31·2
28·9	25	22	20	19	17	16	15	15	13	12	10	8	6	4	2·5	1·7	0·8	0	31·1
29·0	23	20	18	17	16	15	14	13	12	11	9	7	5	3	2·3	1·6	0·7	0	31·0
29·1	20	18	16	15	14	13	13	12	11	10	8	6	5	3	2·1	1·4	0·6	0	30·9
29·2	18	16	15	14	13	12	11	11	9	9	7	6	4	3	1·8	1·3	0·6	0	30·8
29·3	16	14	13	12	11	10	10	9	8	7	6	5	4	2	1·6	1·1	0·5	0	30·7
29·4	14	12	11	10	10	9	8	8	7	6	5	4	3	2	1·4	1·0	0·4	0	30·6
29·5	12	10	9	8	8	7	7	7	6	5	4	4	3	2	1·1	0·8	0·3	0	30·5
29·6	9	8	7	7	6	6	6	5	5	4	4	3	2	1	0·9	0·6	0·3	0	30·4
29·7	6	6	5	5	5	4	4	4	4	3	3	2	2	1	0·7	0·5	0·2	0	30·3
29·8	4	4	4	3	3	3	3	3	2	2	2	1	1	1	0·5	0·3	0·1	0	30·2
29·9	2	2	2	2	2	1	1	1	1	1	1	1	1	0	0·2	0·2	0·1	0	30·1
30·0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0·0	0	0	0	30·0

TABLE VI.

The Sun's Parallax in Altitude and Semidiameter.

Month.	Semid.	Altitude. 0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	Semid.	Month.
	′ ″	″	″	″	″	″	″	″	″	″	″	′ ″	
Jan. 1	16 17	8·7	8·6	8·2	7·6	6·7	5·6	4·4	3·0	1·5	0	16 15	Dec. 1
Feb. 1	16 15	8·7	8·6	8·2	7·6	6·6	5·6	4·3	3·0	1·5	0	16 9	Nov. 1
Mar. 1	16 9	8·6	8·5	8·1	7·5	6·6	5·5	4·3	3·0	1·5	0	16 1	Oct. 1
Apr. 1	16 1	8·5	8·4	8·0	7·4	6·5	5·5	4·3	2·9	1·5	0	15 53	Sept. 1
May 1	15 53	8·4	8·3	8·0	7·3	6·5	5·4	4·2	2·9	1·5	0	15 47	Aug. 1
June 1	15 47	8·4	8·3	8·0	7·3	6·4	5·4	4·2	2·9	1.5	0	15 45	July 1

TABLE VII.

PARALLAX IN ALTITUDE OF A PLANET

Alt.	Planet's Horizontal Parallax 1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	20″	30″
5°	1″·0	2″·0	3″·0	4″·0	5″·0	6″·0	7″·0	8″·0	9″·0	10″·0	19″·9	29″·9
10	1·0	2·0	2·9	3·9	4·9	5·9	6·9	7·9	8·9	9·8	19·7	29·5
15	1·0	2·0	2·9	3·8	4·8	5·8	6·8	7·7	8·7	9·7	19·3	29·0
20	0·9	1·9	2·8	3·7	4·6	5·6	6·5	7·5	8·5	9·4	18·8	28·2
25	0·9	1·9	2·7	3·6	4·5	5·4	6.3	7·3	8·2	9·1	18·1	27·2
30	0·9	1·8	2·6	3·5	4·3	5·2	6·1	7·0	7·8	8·7	17·3	26·0
35	0·8	1·6	2·5	3·3	4·1	4·9	5·7	6·6	7·4	8·2	16·4	24·6
40	0·8	1·5	2·3	3·1	3·8	4·6	5·4	6·1	6·9	7·7	15·3	23·0
45	0·7	1·4	2·1	2·8	3·5	4·2	4·9	5·7	6·4	7·1	14·1	21·2
50	0·7	1·3	2·0	2·5	3·2	3·9	4·5	5·1	5·8	6·4	12·9	19·3
55	0·6	1·1	1·7	2·3	2·8	3·4	4·0	4·6	5·2	5·7	11·5	17·2
60	0·5	1·0	1·5	2·0	2·5	3·0	3·5	4·0	4·5	5·0	10·0	15·0
62	0·5	0·9	1·4	1·9	2·3	2·8	3·3	3·8	4·2	4·7	9·4	14·1
64	0·4	0·9	1·3	1·8	2·2	2·6	3·1	3·5	3·9	4·4	8·8	13·1
66	0·4	0·8	1·2	1·6	2·0	2·4	2·8	3·3	3·7	4·1	8·1	12·2
68	0·4	0·7	1·1	1·5	1·8	2·2	2·6	3·0	3·4	3·7	7·5	11·2
70	0·3	0·7	1·0	1·4	1·7	2·1	2·4	2·7	3·1	3·4	6·8	10·3
72	0·3	0·6	0·9	1·2	1·5	1·9	2·2	2·5	2·8	3·1	6·2	9·3
74	0·3	0·6	0·8	1·1	1·3	1·7	1·9	2·2	2·5	2·7	5·5	8·3
76	0·2	0·5	0·7	0·9	1·2	1·5	1·7	1·9	2·2	2·4	4·8	7·3
78	0·2	0·4	0·6	0·8	1·0	1·2	1·4	1·7	1·9	2·1	4·2	6·2
80	0·2	0·3	0·5	0·7	0·8	1·0	1·2	1·4	1·6	1·7	3·5	5·2
82	0·1	0·3	0·4	0·6	0·7	0·8	1·0	1·1	1·2	1·4	2·8	4·2
84	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9	1·0	2·1	3·1
86	0·1	0·1	0·2	0·3	0·3	0·4	0·5	0·6	0·6	0·7	1·4	2·1
88	0·0	0·1	0·1	0·1	0·1	0·2	0·2	0·3	0·3	0·3	0·7	1·0
90	0	0	0	0	0	0	0	0	0	0	0	0

TABLE VIII.

For Computing the Reduction to the Meridian in Seconds.

S.	0m	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m
	"	"	"	"	"	"	"	"	"	"	"	"
0	0·0	2·0	7·8	17·7	31·4	49·1	70·7	96·2	125·7	159·0	196·3	237·5
1	0·0	2·0	8·0	17·9	31·7	49·4	71·1	96·6	126·2	159·6	197·0	238·3
2	0·0	2·1	8·1	18·1	31·9	49·7	71·5	97·1	126·7	160·2	197·6	239·0
3	0·0	2·2	8·2	18·3	32·2	50·1	71·9	97·6	127·2	160·8	198·3	239·7
4	0·0	2·2	8·4	18·5	32·5	50·4	72·3	98·1	127·8	161·4	198·9	240·4
5	0·0	2·3	8·5	18·7	32·7	50·7	72·7	98·5	128·3	162·0	199·6	241·2
6	0·0	2·4	8·7	18·9	33·0	51·1	73·1	99·0	128·8	162·6	200·3	241·9
7	0·0	2·4	8·8	19·1	33·3	51·4	73·5	99·4	129·4	163·2	200·9	242·6
8	0·0	2·5	8·9	19·3	33·5	51·7	73·9	99·9	129·9	163·8	201·6	243·3
9	0·0	2·6	9·1	19·5	33·8	52·1	74·3	100·4	130·4	164·4	202·2	244·1
10	0·0	2·7	9·2	19·7	34·1	52·4	74·7	100·8	131·0	165·0	202·9	244·8
11	0·1	2·7	9·4	19·9	34·4	52·7	75·1	101·3	131·5	165·6	203·6	245·5
12	0·1	2·8	9·5	20·1	34·6	53·1	75·5	101·8	132·0	166·2	204·2	246·2
13	0·1	2·9	9·6	20·3	34·9	53·4	75·9	102·3	132·6	166·8	204·9	247·0
14	0·1	3·0	9·8	20·5	35·2	53·8	76·3	102·7	133·1	167·4	205·6	247·7
15	0·1	3·1	9·9	20·7	35·5	54·1	76·7	103·2	133·6	168·0	206·3	248·5
16	0·1	3·1	10·1	20·9	35·7	54·5	77·1	103·7	134·2	168·6	206·9	249·2
17	0·2	3·2	10·2	21·2	36·0	54·8	77·5	104·2	134·7	169·2	207·6	249·9
18	0·2	3·3	10·4	21·4	36·3	55·1	77·9	104·6	135·3	169·8	208·3	250·7
19	0·2	3·4	10·5	21·6	36·6	55·5	78·3	105·1	135·8	170·4	208·9	251·4
20	0·2	3·5	10·7	21·8	36·9	55·8	78·8	105·6	136·4	171·0	209·6	252·2
21	0·3	3·6	10·8	22·0	37·2	56·2	79·2	106·1	136·9	171·6	210·3	252·9
22	0·3	3·7	11·0	22·3	37·4	56·5	79·6	106·6	137·4	172·2	211·0	253·6
23	0·3	3·8	11·1	22·5	37·7	56·9	80·0	107·0	138·0	172·9	211·6	254·4
24	0·3	3·8	11·3	22·7	38·0	57·3	80·4	107·5	138·5	173·5	212·3	255·1
25	0·3	3·9	11·5	22·9	38·3	57·6	80·8	108·0	139·1	174·1	213·0	255·9
26	0·4	4·0	11·6	23·1	38·6	58·0	81·3	108·5	139·6	174·7	213·7	256·6
27	0·4	4·1	11·8	23·4	38·9	58·3	81·7	109·0	140·2	175·3	214·4	257·4
28	0·4	4·2	11·9	23·6	39·2	58·7	82·1	109·5	140·7	175·9	215·1	258·1
29	0·5	4·3	12·1	23·8	39·5	59·0	82·5	110·0	141·3	176·6	215·8	258·9
30	0·5	4·4	12·3	24·0	39·8	59·4	83·0	110·4	141·8	177·2	216·4	259·6
31	0·5	4·5	12·4	24·3	40·1	59·8	83·4	110·9	142·4	177·8	217·1	260·4
32	0·6	4·6	12·6	24·5	40·3	60·1	83·8	111·4	143·0	178·4	217·8	261·1
33	0·6	4·7	12·8	24·7	40·6	60·5	84·2	111·9	143·5	179·0	218·5	261·9
34	0·6	4·8	12·9	25·0	40·9	60·8	84·7	112·4	144·1	179·7	219·2	262·6
35	0·7	4·9	13·1	25·2	41·2	61·2	85·1	112·9	144·6	180·3	219·9	263·4
36	0·7	5·0	13·3	25·4	41·5	61·6	85·5	113·4	145·2	180·9	220·6	264·1
37	0·7	5·1	13·4	25·7	41·8	61·9	86·0	113·9	145·8	181·6	221·3	264·9
38	0·8	5·2	13·6	25·9	42·1	62·3	86·4	114·4	146·3	182·2	222·0	265·7
39	0·8	5·3	13·8	26·2	42·5	62·7	86·8	114·9	146·9	182·8	222·7	266·4
40	0·9	5·4	14·0	26·4	42·8	63·0	87·3	115·4	147·5	183·4	223·4	267·2
41	0·9	5·6	14·1	26·6	43·1	63·4	87·7	115·9	148·0	184·1	224·1	267·9
42	1·0	5·7	14·3	26·9	43·4	63·8	88·1	116·4	148·6	184·7	224·8	268·7
43	1·0	5·8	14·5	27·1	43·7	64·2	88·6	116·9	149·2	185·4	225·5	269·5
44	1·1	5·9	14·7	27·4	44·0	64·5	89·0	117·4	149·7	186·0	226·2	270·2
45	1·1	6·0	14·8	27·6	44·3	64·9	89·5	117·9	150·3	186·6	226·9	271·0
46	1·2	6·1	15·0	27·9	44·6	65·3	89·9	118·4	150·9	187·3	227·6	271·8
47	1·2	6·2	15·2	28·1	44·9	65·7	90·3	118·9	151·5	187·9	228·3	272·6
48	1·3	6·4	15·4	28·3	45·2	66·0	90·8	119·5	152·0	188·5	229·0	273·3
49	1·3	6·5	15·6	28·6	45·5	66·4	91·2	120·0	152·6	189·2	229·7	274·1

TABLE VIII.—(*continued*).

For Computing the Reduction to the Meridian in Seconds.

S.	0m	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m
″	″	″	″	″	″	″	″	″	″	″	″	″
50	1·4	6·6	15·8	28·8	45·9	66·8	91·7	120·5	153·2	189·8	230·4	274·9
51	1·4	6·7	15·9	29·1	45·2	67·2	92·1	121·0	153·8	190·5	231·1	275·6
52	1·5	6·8	16·1	29·4	46·5	67·6	92·6	121·5	154·4	191·1	231·8	276·4
53	1·5	7·0	16·3	29·6	46·8	68·0	93·0	122·0	154·9	191·8	232·5	277·2
54	1·6	7·1	16·5	29·9	47·1	68·3	93·5	122·5	155·5	192·4	233·3	278·0
55	1·6	7·2	16·7	30·1	47·5	68·7	93·9	123·1	156·1	193·1	234·0	278·9
56	1·7	7·3	16·9	30·4	47·8	69·1	94·4	123·6	156·7	193·7	234·7	279·5
57	1·8	7·5	17·1	30·6	48·1	69·5	94·8	124·1	157·3	194·4	235·4	280·3
58	1·8	7·6	17·3	30·9	48·4	69·9	95·3	124·6	157·8	195·0	236·1	281·1
59	1·9	7·7	17·5	31·1	48·8	70·3	95·7	125·1	158·4	195·7	236·8	281·9
60	2·0	7·8	17·7	31·4	49·1	70·7	96·2	125·7	159·0	196·3	237·5	282·7

S.	12m	13m	14m	15m	16m	17m	18m	19m	20m
	″	″	″	″	″	″	″	″	″
0	282·7	331·8	384·7	441·6	502·5	567·1	635·8	708·3	784·9
1	283·5	332·6	385·6	442·6	503·5	568·2	636·9	709·5	786·2
2	284·2	333·4	386·5	443·6	504·6	569·3	638·1	710·8	787·5
3	285·0	334·3	387·5	444·6	505·6	570·4	639·3	712·1	788·8
4	285·8	335·2	388·4	445·6	506·7	571·6	640·5	713·4	790·1
5	286·6	336·0	389·3	446·5	507·7	572·7	641·7	714·6	791·4
6	287·4	336·9	390·2	447·5	508·8	573·8	642·9	715·9	792·7
7	288·2	337·7	391·1	448·5	509·8	574·9	644·1	717·1	794·0
8	289·0	338·6	392·1	449·5	510·9	576·1	645·3	718·4	795·4
9	289·8	339·4	393·0	450·5	511·9	577·2	646·4	719·6	796·7
10	290·6	340·3	393·9	451·5	513·0	578·3	647·6	720·9	798·0
11	291·4	341·2	394·8	452·5	514·0	579·4	648·8	722·1	799·3
12	292·2	342·0	395·8	453·5	515·1	580·6	650·0	723·4	800·7
13	293·0	342·9	396·7	454·5	516·1	581·7	651·2	724·6	802·0
14	293·8	343·7	397·6	455·5	517·2	582·8	652·4	725·9	803·3
15	294·6	344·6	398·6	456·5	518·3	583·9	653·6	727·1	804·6
16	295·4	345·5	399·5	457·5	519·4	585·1	654·8	728·4	806·0
17	296·2	346·3	400·5	458·5	520·4	586·2	656·0	729·6	807·3
18	297·0	347·2	401·4	459·5	521·4	587·3	657·2	730·9	808·6
19	297·8	348·1	402·3	460·5	522·5	588·4	658·4	732·2	809·9
20	298·6	349·0	403·3	461·5	523·5	589·6	659·6	733·5	811·3
21	299·4	349·8	404·2	462·5	524·6	590·7	660·8	734·7	812·6
22	300·2	350·7	405·1	463·5	525·7	591·9	662·0	736·0	813·9
23	301·0	351·6	406·0	464·5	526·8	593·0	663·2	737·2	815·2
24	301·8	352·5	407·0	465·5	527·9	594·1	664·4	738·5	816·6
25	302·6	353·3	408·0	466·5	528·9	595·2	665·6	739·7	817·9
26	303·5	354·2	408·9	467·5	530·0	596·4	666·8	741·0	819·2
27	304·3	355·1	409·9	468·5	531·1	597·5	668·0	742·3	820·5
28	305·1	356·0	410·8	469·5	532·2	508·7	669·2	743·6	821·9
29	305·9	356·9	411·7	470·5	533·2	599·8	670·4	744·8	823·2

TABLE VIII.—(*continued*).
For Computing the Reduction to the Meridian in Seconds.

S.	12m	13m	14m	15m	16m	17m	18m	19m	20m
	"	"	"	"	"	"	"	"	"
30	306·7	357·7	412·7	471·5	534·3	601·0	671·6	746·1	824·6
31	307·5	358·6	413·6	472·6	535·4	602·1	672·8	747·4	825·9
32	308·4	359·5	414·6	473·6	536·5	603·3	674·1	748·7	827·3
33	309·2	360·3	415·6	474·6	537·5	604·4	675·3	749·9	828·6
34	310·0	361·2	416·6	475·6	538·6	605·6	676·5	751·2	829·9
35	310·8	362·1	417·5	476·6	539·7	606·7	677·7	752·5	831·2
36	311·6	363·0	418·4	477·6	540·8	607·9	678·9	753·8	832·6
37	312·5	363·9	419·4	478·7	541·9	609·0	680·1	755·0	833·9
38	313·3	364·8	420·3	479·7	543·0	610·2	681·3	756·3	835·3
39	314·2	365·7	421·3	480·7	544·1	611·3	682·5	757·6	836·6
40	315·0	366·5	422·2	481·7	545·2	612·5	683·8	758·9	838·0
41	315·8	367·5	423·2	482·8	546·2	613·6	685·0	760.2	839·3
42	316·6	368·4	424·2	483·8	547·3	614·8	686·2	761·5	840·7
43	317·4	369·3	425·1	484·8	548·4	615·9	687·4	762·8	842·0
44	318·3	370·2	426·1	485·8	549·5	617·1	688·7	764·0	843·4
45	319·1	371·1	427·0	486·9	550·6	618·2	689·9	765·3	844·7
46	319·9	372·0	428·0	487·9	551·7	619·4	691·1	766·6	846·1
47	320·8	372·9	429·0	488·9	552·8	620·5	692·3	767·9	847·5
48	321·6	373·8	430·0	490·0	553·9	621·7	693·6	769·2	848·9
49	322·4	374·7	430·9	491·0	555·0	622·8	694·8	770·5	850·2
50	323·3	375·6	431·9	492·0	556·1	624·0	696·0	771·8	851·6
51	324·1	376·5	432·8	493·1	557·2	625·2	697·2	773·1	852·9
52	325·0	377·4	433·8	494·1	558·3	626·4	698·4	774·5	854·3
53	325·8	378·3	434·8	495·2	559·4	627·5	699·6	775·8	855·6
54	326·7	379·2	435·7	496·2	560·5	628·7	700·9	777·1	857·1
55	327·5	380·2	436·7	497·2	561·6	629·9	702·2	778·4	858·4
56	328·4	381·1	437·7	498·2	562·7	631·1	703·5	779·7	859·8
57	329·2	382·0	438·7	499·2	563·8	632·2	704·7	781·0	861·1
58	330·0	382·9	439·6	500·3	564·9	633·4	705·9	782·3	862·5
59	330·9	383·8	440·6	501·4	566·0	634·6	707·1	783·6	863·9
60	331·8	384·7	441·6	502·5	567·1	635·8	708·3	784·9	865·3

S.	21m	22m	23m	24m	25m	26m	27m	28m	29m	30m
	"	"	"	"	"	"	"	"	"	"
0	865·3	949·6	1037·8	1129·9	1225·9	1325·9	1429·7	1537·5	1649·0	1764·6
1	866·6	951·0	1039·3	1131·4	1227·5	1327·6	1431·4	1539·3	1650·9	1766·6
2	868·0	952·4	1040·8	1133·0	1229·2	1329·3	1433·2	1541·1	1652·8	1768·5
3	869·4	953·8	1042·3	1134·6	1230·8	1331·0	1434·9	1542·9	1654·7	1770·5
4	870·8	955·3	1043·8	1136·2	1232·5	1332·7	1436·7	1544·8	1656·6	1772·4
5	872·1	956·7	1045·3	1137·8	1234·1	1334·4	1438·5	1546·6	1658·5	1774·4
6	873·5	958·2	1046·8	1139·3	1235·7	1336·1	1440·3	1548·4	1660·4	1776·3
7	874·9	959·6	1048·3	1140·9	1237·3	1337·8	1442·1	1550·2	1662·3	1778·3
8	876·3	961·1	1049·8	1142·5	1239·0	1339·5	1443·9	1552·1	1664·2	1780·3
9	877·6	962·5	1051·3	1144·0	1240·6	1341·2	1445·6	1553·9	1666·1	1782·3

TABLE VIII.—(*continued*).

For Computing the Reduction to the Meridian in Seconds.

S.	21m	22m	23m	24m	25m	26m	27m	28m	29m	30m
	″	″	″	″	″	″	″	″	″	″
10	879·0	963·9	1052·8	1145·6	1242·3	1342·9	1447·4	1555·8	1668·0	1784·2
11	880·4	965·4	1054·3	1147·2	1243·9	1344·6	1449·2	1557·6	1669·9	1786·2
12	881·8	966·9	1055·9	1148·8	1245·6	1346·3	1451·0	1559·5	1671·9	1788·2
13	883·2	968·3	1057·4	1150·4	1247·2	1348·0	1452·8	1561·3	1673·8	1790·1
14	884·6	969·8	1058·9	1152·0	1248·9	1349·7	1454·5	1563·2	1675·7	1792·1
15	886·0	971·2	1060·4	1153·6	1250·5	1351·4	1456·3	1565·0	1677·6	1794·1
16	887·4	972·7	1062·0	1155·2	1252·2	1353·2	1458·1	1566·9	1679·5	1796·1
17	888·8	974·1	1063·5	1156·8	1253·8	1354·9	1459·9	1568·7	1681·4	1798·1
18	890·2	975·5	1065·0	1158·3	1255·5	1356·6	1461·6	1570·5	1683·3	1800·0
19	891·6	977·0	1066·5	1159·9	1257·1	1358·3	1463·4	1572·4	1685·2	1802·0
20	893·0	978·5	1068·1	1161·5	1258·8	1360·1	1465·2	1574·3	1687·2	1804·0
21	894·4	979·9	1069·6	1163·1	1260·4	1361·8	1466·9	1576·1	1689·1	1805·9
22	895·8	981·4	1071·1	1164·7	1262·1	1363·5	1468·7	1578·0	1691·0	1807·9
23	897·2	982·9	1072·6	1166·3	1263·7	1365·2	1470·5	1579·8	1692·9	1809·9
24	898·6	984·4	1074·2	1167·9	1265·4	1367·0	1472·3	1581·7	1694·8	1811·9
25	900·0	985·8	1075·7	1169·5	1267·0	1368·7	1474·0	1583·5	1696·7	1813·9
26	901·4	987·3	1077·2	1171·1	1268·7	1370·4	1475·9	1585·3	1698·6	1815·8
27	902·8	988·8	1078·7	1172·7	1270·3	1372·1	1477·7	1587·2	1700·5	1817·8
28	904·2	990·3	1080·3	1174·8	1272·0	1373·9	1479·5	1589·1	1702·5	1819·8
29	905·6	991·8	1081·8	1175·9	1273·7	1375·6	1481·3	1590·9	1704·4	1821·8
30	907·0	993·2	1083·3	1177·5	1275·4	1377·4	1483·1	1592·7	1706·3	1823·8
31	908·4	994·7	1084·8	1179·1	1277·1	1379·1	1484·9	1594·6	1708·2	1825·8
32	909·8	996·2	1086·4	1180·7	1278·8	1380·8	1486·7	1596·5	1710·2	1827·8
33	911·2	997·6	1087·9	1182·3	1280·4	1382·5	1488·5	1598·3	1712·1	1829·8
34	912·6	999·1	1089·5	1183·9	1282·1	1384·2	1490·3	1600·2	1714·0	1831·8
35	914·0	1000·6	1091·0	1185·5	1283·8	1385·9	1492·1	1602·1	1715·9	1833·8
36	915·5	1002·1	1092·6	1187·1	1285·5	1387·7	1493·9	1604·0	1717·9	1835·8
37	916·9	1003·5	1094·1	1188·7	1287·1	1389·4	1495·7	1605·9	1719·8	1837·8
38	918·3	1005·0	1095·7	1190·3	1288·8	1391·2	1497·5	1607·7	1721·7	1839·8
39	919·7	1006·5	1097·2	1191·9	1290·5	1392·9	1499·3	1609·6	1723·6	1841·8
40	921·1	1008·0	1098·8	1193·5	1292·2	1394·7	1501·1	1611·5	1725·6	1843·8
41	922·5	1009·4	1100·3	1195·1	1293·8	1396·4	1502·9	1613·3	1727·5	1845·8
42	923·9	1010·9	1101·9	1196·7	1295·5	1398·2	1504·7	1615·2	1729·5	1847·8
43	925·3	1012·4	1103·4	1198·3	1297·2	1399·9	1506·5	1617·1	1731·5	1849·8
44	926·8	1013·9	1105·0	1199·9	1298·9	1401·7	1508·4	1619·0	1733·4	1851·8
45	928·2	1015·4	1106·5	1201·5	1300·5	1403·4	1510·2	1620·8	1735·3	1853·8
46	929·6	1016·9	1108·1	1203·1	1302·2	1405·2	1512·0	1622·7	1737·2	1855·8
47	931·0	1018·4	1109·6	1204·7	1303·9	1406·9	1513·8	1624·6	1739·2	1857·8
48	932·4	1019·9	1111·2	1206·4	1305·6	1408·7	1515·6	1626·5	1741·2	1859·8
49	933·8	1021·4	1112·7	1208·0	1307·3	1410·4	1517·4	1628·3	1743·1	1861·8
50	935·2	1022·8	1114·3	1209·6	1309·0	1412·2	1519·2	1630·2	1745·1	1863·8
51	936·6	1024·3	1115·8	1211·2	1310·7	1413·9	1521·0	1632·1	1747·0	1865·8
52	938·1	1025·8	1117·4	1212·0	1312·4	1415·7	1522·9	1634·0	1749·0	1867·8
53	939·5	1027·3	1118·9	1214·5	1314·1	1417·4	1524·7	1635·9	1750·9	1869·8
54	940·9	1028·8	1120·5	1216·1	1315·7	1419·2	1526·5	1637·7	1752·9	1871·8
55	942·3	1030·3	1122·0	1217·7	1317·4	1420·9	1528·3	1639·6	1754·8	1873·8
56	943·8	1031·8	1123·6	1218·4	1319·1	1422·7	1530·2	1641·5	1756·8	1875·9
57	945·2	1033·3	1125·1	1221·0	1320·8	1424·4	1532·0	1643·3	1758·7	1877·9
58	946·6	1034·8	1126·7	1222·6	1322·5	1426·2	1533·8	1645·2	1760·7	1879·9
59	948·1	1036·3	1128·3	1224·2	1324·2	1427·9	1535·6	1647·1	1762·6	1882·0
60	949·6	1037·8	1129·9	1225·9	1325·9	1429·7	1537·5	1649·0	1764·6	1884·0

TABLE IX.

Graticules for Map Projections.

Latitude.	Length of 15′ of Latitude in Statute Miles.	Length of Diagonal in Statute Miles.	Latitude.	Length of 15′ of Longitude in Statute Miles.
° ′ ° ′			° ′	
			At 0 0	17·294
From 0 0 to 0 15	17·176	24·374	0 15	293
0 15 „ 0 30	176	373	0 30	292
0 30 „ 0 45	176	372	0 45	291
0 45 „ 1 0	176	371	1 0	290
1 0 „ 1 15	176	371	1 15	288
1 15 „ 1 30	176	369	1 30	286
1 30 „ 1 45	176	367	1 45	284
1 45 „ 2 0	176	366	2 0	282
2 0 „ 2 15	176	364	2 15	279
2 15 „ 2 30	176	362	2 30	276
2 30 „ 2 45	176	359	2 45	273
2 45 „ 3 0	176	356	3 0	270
3 0 „ 3 15	176	353	3 15	265
3 15 „ 3 30	176	350	3 30	261
3 30 „ 3 45	176	348	3 45	256
3 45 „ 4 0	176	345	4 0	252
4 0 „ 4 15	176	342	4 15	246
4 15 „ 4 30	176	338	4 30	240
4 30 „ 4 45	177	333	4 45	234
4 45 „ 5 0	177	328	5 0	228
5 0 „ 5 15	178	326	5 15	221
5 15 „ 5 30	178	321	5 30	214
5 30 „ 5 45	178	316	5 45	207
5 45 „ 6 0	178	311	6 0	200
6 0 „ 6 15	178	306	6 15	191
6 15 „ 6 30	178	299	6 30	183
6 30 „ 6 45	178	293	6 45	174
6 45 „ 7 0	178	286	7 0	166
7 0 „ 7 15	178	279	7 15	156
7 15 „ 7 30	178	272	7 30	146
7 30 „ 7 45	179	266	7 45	136
7 45 „ 8 0	179	259	8 0	126
8 0 „ 8 15	180	253	8 15	115
8 15 „ 8 30	180	245	8 30	104
8 30 „ 8 45	180	237	8 45	093
8 45 „ 9 0	180	230	9 0	082
9 0 „ 9 15	180	222	9 15	069
9 15 „ 9 30	180	214	9 30	057
9 30 „ 9 45	181	207	9 45	044
9 45 „ 10 0	181	199	10 0	032
10 0 „ 10 15	182	192	10 15	028
10 15 „ 10 30	182	181	10 30	015
10 30 „ 10 45	182	171	10 45	001
10 45 „ 11 0	182	160	11 0	16·978
11 0 „ 11 15	182	150	11 15	963
11 15 „ 11 30	182	139	11 30	948
11 30 „ 11 45	182	129	11 45	933

TABLE IX.—(*continued*).

Graticules for Map Projections.

Latitude.	Length of 15′ of Latitude in Statute Miles.	Length of Diagonal in Statute Miles.	Latitude.	Length of 15′ of Longitude in Statute Miles.
° ′ ° ′			° ′	
From 11 45 to 12 0	17·183	24·118	At 12 0	16·918
12 0 ,, 12 15	183	108	12 15	901
12 15 ,, 12 30	183	096	12 30	885
12 30 ,, 12 45	183	085	12 45	868
12 45 ,, 13 0	184	073	13 0	852
13 0 ,, 13 15	184	062	13 15	834
13 15 ,, 13 30	184	050	13 30	817
13 30 ,, 13 45	185	038	13 45	799
13 45 ,, 14 0	185	026	14 0	782
14 0 ,, 14 15	186	014	14 15	763
14 15 ,, 14 30	186	001	14 30	745
14 30 ,, 14 45	187	23·988	14 45	726
14 45 ,, 15 0	187	976	15 0	708
15 0 ,, 15 15	188	963	15 15	688
15 15 ,, 15 30	188	950	15 30	668
15 30 ,, 15 45	189	936	15 45	648
15 45 ,, 16 0	189	923	16 0	628
16 0 ,, 16 15	190	910	16 15	606
16 15 ,, 16 30	190	895	16 30	585
16 30 ,, 16 45	190	879	16 45	563
16 45 ,, 17 0	191	864	17 0	542
17 0 ,, 17 15	191	849	17 15	519
17 15 ,, 17 30	191	834	17 30	497
17 30 ,, 17 45	191	819	17 45	474
17 45 ,, 18 0	192	805	18 0	452
18 0 ,, 18 15	192	790	18 15	428
18 15 ,, 18 30	192	773	18 30	404
18 30 ,, 18 45	193	756	18 45	380
18 45 ,, 19 0	193	739	19 0	356
19 0 ,, 19 15	194	722	19 15	331
19 15 ,, 19 30	194	705	19 30	306
19 30 ,, 19 45	195	688	19 45	281
19 45 ,, 20 0	195	671	20 0	256
20 0 ,, 20 15	196	654	20 15	230
20 15 ,, 20 30	196	636	20 30	204
20 30 ,, 20 45	197	618	20 45	178
20 45 ,, 21 0	197	601	21 0	152
21 0 ,, 21 15	198	583	21 15	124
21 15 ,, 21 30	198	565	21 30	097
21 30 ,, 21 45	199	546	21 45	069
21 45 ,, 22 0	199	528	22 0	042
22 0 ,, 22 15	200	510	22 15	013
22 15 ,, 22 30	200	490	22 30	15·984
22 30 ,, 22 45	201	471	22 45	955
22 45 ,, 23 0	201	451	23 0	926
23 0 ,, 23 15	202	432	23 15	896
23 15 ,, 23 30	203	412	23 30	867
23 30 ,, 23 45	204	393	23 45	837

TABLE IX.—(*continued*).

Graticules for Map Projections.

Latitude.	Length of 15′ of Latitude in Statute Miles.	Length of Diagonal in Statute Miles.	Latitude.	Length of 15′ of Longitude in Statute Miles.
° ′ ° ′			° ′	
From 23 45 to 24 0	17·205	23·373	At 24 0	15·808
24 0 „ 24 15	206	354	24 15	776
24 15 „ 24 30	206	333	24 30	745
24 30 „ 24 45	207	312	24 45	713
24 45 „ 25 0	207	292	25 0	682
25 0 „ 25 15	208	271	25 15	650
25 15 „ 25 30	208	250	25 30	618
25 30 „ 25 45	209	228	25 45	586
25 45 „ 26 0	209	207	26 0	554
26 0 „ 26 15	210	186	26 15	520
26 15 „ 26 30	210	163	26 30	486
26 30 „ 26 45	211	141	26 45	452
26 45 „ 27 0	211	118	27 0	418
27 0 „ 27 15	212	096	27 15	383
27 15 „ 27 30	212	073	27 30	349
27 30 „ 27 45	213	051	27 45	314
27 45 „ 28 0	213	028	28 0	280
28 0 „ 28 15	214	006	28 15	244
28 15 „ 28 30	215	22·983	28 30	209
28 30 „ 28 45	216	960	28 45	173
28 45 „ 29 0	217	937	29 0	138
29 0 „ 29 15	218	914	29 15	101
29 15 „ 29 30	218	884	29 30	064
29 30 „ 29 45	219	853	29 45	027
29 45 „ 30 0	219	823	30 0	14·990
30 0 „ 30 15	220	793	30 15	952
30 15 „ 30 30	220	773	30 30	914
30 30 „ 30 45	221	753	30 45	876
30 45 „ 31 0	221	734	31 0	838
31 0 „ 31 15	222	714	31 15	798
31 15 „ 31 30	223	690	31 30	759
31 30 „ 31 45	224	666	31 45	719
31 45 „ 32 0	225	643	32 0	680
32 0 „ 32 15	226	619	32 15	639
32 15 „ 32 30	226	593	32 30	599
32 30 „ 32 45	227	567	32 45	558
32 45 „ 33 0	227	542	33 0	518
33 0 „ 33 15	228	516	33 15	476
33 15 „ 33 30	229	490	33 30	434
33 30 „ 33 45	230	463	33 45	392
33 45 „ 34 0	231	437	34 0	350
34 0 „ 34 15	232	411	34 15	308
34 15 „ 34 30	232	384	34 30	266
34 30 „ 34 45	233	358	34 45	224
34 45 „ 35 0	233	331	35 0	182
35 0 „ 35 15	234	305	35 15	138
35 15 „ 35 30	234	277	35 30	094
35 30 „ 35 45	235	250	35 45	050

TABLE IX.—(*continued*).

Graticules for Map Projections.

Latitude.					Length of 15′ of Latitude in Statute Miles.	Length of Diagonal in Statute Miles.	Latitude.			Length of 15′ of Longitude in Statute Miles.
	°	′	°	′				°	′	
From	35	45 to	36	0	17·235	22·222	At	36	0	14·006
	36	0 ,,	36	15	236	195		36	15	13·961
	36	15 ,,	36	30	237	168		36	30	917
	36	30 ,,	36	45	238	140		36	45	872
	36	45 ,,	37	0	239	113		37	0	828
	37	0 ,,	37	15	240	086		37	15	782
	37	15 ,,	37	30	240	058		37	30	736
	37	30 ,,	37	45	241	025		37	45	690
	37	45 ,,	38	0	241	001		38	0	644
	38	0 ,,	38	15	242	21·973		38	15	597
	38	15 ,,	38	30	243	945		38	30	551
	38	30 ,,	38	45	244	917		38	45	504
	38	45 ,,	39	0	245	889		39	0	458
	39	0 ,,	39	15	246	861		39	15	410
	39	15 ,,	39	30	247	831		39	30	362
	39	30 ,,	39	45	248	801		39	45	314
	39	45 ,,	40	0	249	771		40	0	256
	40	0 ,,	40	15	250	741		40	15	217
	40	15 ,,	40	30	250	713		40	30	168
	40	30 ,,	40	45	251	685		40	45	119
	40	45 ,,	41	0	251	657		41	0	070
	41	0 ,,	41	15	252	629		41	15	020
	41	15 ,,	41	30	252	599		41	30	12·970
	41	30 ,,	41	45	253	569		41	45	920
	41	45 ,,	42	0	253	540		42	0	870
	42	0 ,,	42	15	254	510		42	15	819
	42	15 ,,	42	30	255	481		42	30	769
	42	30 ,,	42	45	256	451		42	45	718
	42	45 ,,	43	0	257	422		43	0	668
	43	0 ,,	43	15	258	393		43	15	616
	43	15 ,,	43	30	259	363		43	30	564
	43	30 ,,	43	45	260	333		43	45	512
	43	45 ,,	44	0	261	304		44	0	460
	44	0 ,,	44	15	262	274		44	15	407
	44	15 ,,	44	30	262	243		44	30	354
	44	30 ,,	44	45	263	213		44	45	301
	44	45 ,,	45	0	263	182		45	0	248
	45	0 ,,	45	15	264	152		45	15	194
	45	15 ,,	45	30	265	122		45	30	141
	45	30 ,,	45	45	266	092		45	45	087
	45	45 ,,	46	0	267	062		46	0	034
	46	0 ,,	46	15	268	032		46	15	11·979
	46	15 ,,	46	30	268	001		46	30	925
	46	30 ,,	46	45	269	20·970		46	45	870
	46	45 ,,	47	0	269	940		47	0	816
	47	0 ,,	47	15	270	909		47	15	760
	47	15 ,,	47	30	271	879		47	30	705
	47	30 ,,	47	45	272	848		47	45	649

TABLE IX.—(*continued*).

Graticules for Map Projections.

Latitude.	Length of 15′ of Latitude in Statute Miles.	Length of Diagonal in Statute Miles.	Latitude.	Length of 15′ of Longitude in Statute Miles.
° ′ ° ′			° ′	
From 47 45 to 48 0	17·273	20·818	At 48 0	11·594
48 0 „ 48 15	274	788	48 15	537
48 15 „ 48 30	274	757	48 30	481
48 30 „ 48 45	275	726	48 45	424
48 45 „ 49 0	275	696	49 0	368
49 0 „ 49 15	276	665	49 15	310
49 15 „ 49 30	277	634	49 30	253
49 30 „ 49 45	278	604	49 45	195
49 45 „ 50 0	279	573	50 0	138
50 0 „ 50 15	280	543	50 15	080
50 15 „ 50 30	280	512	50 30	022
50 30 „ 50 45	281	481	50 45	10·964
50 45 „ 51 0	281	451	51 0	906
51 0 „ 51 15	282	420	51 15	847
51 15 „ 51 30	283	389	51 30	788
51 30 „ 51 45	283	358	51 45	729
51 45 „ 52 0	284	328	52 0	670
52 0 „ 52 15	285	297	52 15	610
52 15 „ 52 30	286	267	52 30	550
52 30 „ 52 45	286	236	52 45	490
52 45 „ 53 0	287	206	53 0	430
53 0 „ 53 15	288	176	53 15	369
53 15 „ 53 30	289	145	53 30	309
53 30 „ 53 45	290	115	53 45	248
53 45 „ 54 0	291	084	54 0	188
54 0 „ 54 15	292	054	54 15	126
54 15 „ 54 30	292	023	54 30	065
54 30 „ 54 45	293	19·993	54 45	003
54 45 „ 55 0	293	962	55 0	9·942
55 0 „ 55 15	294	932	55 15	879
55 15 „ 55 30	295	902	55 30	817
55 30 „ 55 45	296	872	55 45	754
55 45 „ 56 0	297	843	56 0	692
56 0 „ 56 15	298	813	56 15	629
56 15 „ 56 30	298	783	56 30	567
56 30 „ 56 45	299	753	56 45	504
56 45 „ 57 0	299	723	57 0	442
57 0 „ 57 15	300	693	57 15	378
57 15 „ 57 30	301	663	57 30	314
57 30 „ 57 45	301	634	57 45	250
57 45 „ 58 0	302	604	58 0	186
58 0 „ 58 15	303	575	58 15	121
58 15 „ 58 30	304	546	58 30	057
58 30 „ 58 45	304	516	58 45	8·992
58 45 „ 59 0	305	487	59 0	928
59 0 „ 59 15	306	458	59 15	863
59 15 „ 59 30	306	429	59 30	798
59 30 „ 59 45	307	400	59 45	734

TABLE IX.—(*continued*).

Graticules for Map Projections.

Latitude.	Length of 15′ of Latitude in Statute Miles.	Length of Diagonal in Statute Miles.	Latitude.	Length of 15′ of Longitude in Statute Miles.
° ′ ° ′			° ′	
From 59 45 to 60 0	17·307	19·372	At 60 0	8·669
60 0 ,, 60 15	308	343	60 15	603
60 15 ,, 60 30	309	327	60 30	537
60 30 ,, 60 45	310	314	60 45	472
60 45 ,, 61 0	310	286	61 0	406
61 0 ,, 61 15	311	257	61 15	339
61 15 ,, 61 30	312	229	61 30	273
61 30 ,, 61 45	312	201	61 45	197
61 45 ,, 62 0	313	170	62 0	121
62 0 ,, 62 15	314	139	62 15	054
62 15 ,, 62 30	314	120	62 30	7·987
62 30 ,, 62 45	315	081	62 45	930
62 45 ,, 63 0	316	056	63 0	872
63 0 ,, 63 15	316	033	63 15	805
63 15 ,, 63 30	317	097	63 30	737
63 30 ,, 63 45	317	18·981	63 45	669
63 45 ,, 64 0	318	953	64 0	602
64 0 ,, 64 15	319	926	64 15	536
64 15 ,, 64 30	319	901	64 30	466
64 30 ,, 64 45	320	873	64 45	397
64 45 ,, 65 0	320	847	65 0	329
65 0 ,, 65 15	321	820	65 15	260
65 15 ,, 65 30	322	794	65 30	192
65 30 ,, 65 45	322	769	65 45	123
65 45 ,, 66 0	323	742	66 0	054
66 0 ,, 66 15	323	717	66 15	6·985
66 15 ,, 66 30	324	691	66 30	914
66 30 ,, 66 45	324	666	66 45	846
66 45 ,, 67 0	325	640	67 0	776
67 0 ,, 67 15	326	616	67 15	708
67 15 ,, 67 30	326	591	67 30	637
67 30 ,, 67 45	327	566	67 45	567
67 45 ,, 68 0	327	542	68 0	497
68 0 ,, 68 15	328	517	68 15	427
68 15 ,, 68 30	328	494	68 30	357
68 30 ,, 68 45	329	469	68 45	286
68 45 ,, 69 0	329	446	69 0	216
69 0 ,, 69 15	330	422	69 15	145
69 15 ,, 69 30	330	399	69 30	070
69 30 ,, 69 45	331	375	69 45	027
69 45 ,, 70 0	331	356	70 0	5·980

TABLE X.

Determination of Heights by Boiling Point Thermometer.

Boiling point Fahr.	Altitude above level at which water boils at 212° (temp. of intermediate air being 32° F.).	Approximate corresponding height of aneroid or barometer.	Boiling point Fahr.	Altitude above level at which water boils at 212° (temp. of intermediate air being 32° F.).	Approximate corresponding height of aneroid or barometer.	Boiling point Fahr.	Altitude above level at which water boils at 212° (temp. of intermediate air being 32° F.).	Approximate corresponding height of aneroid or barometer.
185·0	14698	17·048	190·0	11872	18·996	195·0	9095	21·126
·1	14641	17·085	·1	11816	19·036	·1	9040	21·171
·2	14584	17·122	·2	11760	19·077	·2	8985	21·216
·3	14528	17·160	·3	11704	19·118	·3	8930	21·260
·4	14471	17·197	·4	11648	19·159	·4	8875	21·305
·5	14414	17·235	·5	11592	19·200	·5	8820	21·350
·6	14357	17·272	·6	11536	19·241	·6	8765	21·395
·7	14300	17·310	·7	11480	19·283	·7	8710	21·440
·8	14244	17·348	·8	11424	19·324	·8	8655	21·485
·9	14187	17·385	·9	11368	19·365	·9	8600	21·530
186·0	14130	17·423	191·0	11312	19·407	196·0	8545	21·576
·1	14073	17·461	·1	11257	19·448	·1	8490	21·621
·2	14017	17·499	·2	11201	19·490	·2	8435	21·666
·3	13960	17·537	·3	11146	19·532	·3	8381	21·712
·4	13903	17·575	·4	11090	19·573	·4	8326	21·751
·5	13857	17·614	·5	11034	19·615	·5	8271	21·803
·6	13790	17·652	·6	10978	19·657	·6	8216	21·849
·7	13733	17·690	·7	10922	19·699	·7	8161	21·895
·8	13676	17·729	·8	10867	19·741	·8	8107	21·941
·9	13620	17·767	·9	10811	19·783	·9	8052	21·987
187·0	13563	17·806	192·0	10755	19·825	197·0	7997	22·033
·1	13506	17·844	·1	10699	19·868	·1	7942	22·079
·2	13450	17·883	·2	10644	19·910	·2	7888	22·125
·3	13394	17·922	·3	10588	19·952	·3	7833	22·172
·4	13337	17·961	·4	10533	19·995	·4	7779	22·218
·5	13281	18·000	·5	10477	20·037	·5	7724	22·264
·6	13224	18·039	·6	10422	20·080	·6	7669	22·311
·7	13167	18·078	·7	10366	20·123	·7	7615	22·358
·8	13111	18·117	·8	10310	20·166	·8	7560	22·404
·9	13054	18·156	·9	10255	20·208	·9	7506	22·451
188·0	12998	18·195	193·0	10199	20·251	198·0	7451	22·498
·1	12942	18·235	·1	10144	20·294	·1	7397	22·545
·2	12885	18·274	·2	10088	20·338	·2	7343	22·592
·3	12829	18·314	·3	10033	20·381	·3	7289	22·639
·4	12772	18·353	·4	9978	20·424	·4	7234	22·686
·5	12716	18·393	·5	9923	20·467	·5	7180	22·734
·6	12660	18·432	·6	9867	20·511	·6	7125	22·781
·7	12603	18·472	·7	9812	20·554	·7	7071	22·829
·8	12547	18·512	·8	9757	20·598	·8	7016	22·876
·9	12490	18·552	·9	9701	20·641	·9	6962	22·924
189·0	12434	18·592	194·0	9646	20·685	199·0	6908	22·971
·1	12377	18·632	·1	9591	20·729	·1	6854	23·019
·2	12321	18·672	·2	9536	20·773	·2	6800	23·067
·3	12265	18·712	·3	9481	20·817	·3	6745	23·115
·4	12209	18·753	·4	9426	20·861	·4	6691	23·163
·5	12153	18·793	·5	9371	20·905	·5	6637	23·211
·6	12096	18·833	·6	9315	20·949	·6	6583	23·259
·7	12040	18·874	·7	9260	20·993	·7	6529	23·308
·8	11984	18·914	·8	9205	21·038	·8	6474	23·356
·9	11928	18·955	·9	9150	21·082	·9	6420	23·405

TABLE X.—(*continued*).

Determination of Heights by Boiling Point Thermometer.

Boiling point Fahr.	Altitude above level at which water boils at 212° (temp. of intermediate air being 32° F.).	Approximate corresponding height of aneroid or barometer.	Boiling point Fahr.	Altitude above level at which water boils at 212° (temp. of intermediate air being 32° F.).	Approximate corresponding height of aneroid or barometer.	Boiling point Fahr.	Altitude above level at which water boils at 212° (temp. of intermediate air being 32° F.).	Approximate corresponding height of aneroid or barometer.
200·0	6366	23·453	205·0	3682	25·990	210·0	1044	28·751
·1	6312	23·502	·1	3625	26·043	·1	992	28·809
·2	6258	23·550	·2	3574	26·096	·2	939	28·866
·3	6203	23·599	·3	3521	26·149	·3	887	28·924
·4	6149	23·648	·4	3468	26·202	·4	835	28·982
·5	6095	23·697	·5	3416	26·255	·5	783	29·040
·6	6041	23·746	·6	3363	26·309	·6	730	29·098
·7	5987	23·795	·7	3310	26·362	·7	678	29·156
·8	5933	23·845	·8	3256	26·416	·8	626	29·215
·9	5879	23·894	·9	3203	26·470	·9	573	29·273
201·0	5825	23·943	206·0	3151	26·523	211·0	521	29·331
·1	5771	23·993	·1	3098	26·577	·1	469	29·390
·2	5717	24·042	·2	3045	26·631	·2	417	29·449
·3	5663	24·092	·3	2992	26·685	·3	365	29·508
·4	5609	24·142	·4	2939	26·740	·4	313	29·566
·5	5556	24·191	·5	2886	26·794	·5	261	29·625
·6	5502	24·241	·6	2833	26·848	·6	208	29·684
·7	5448	24·291	·7	2780	26·903	·7	156	29·744
·8	5394	24·341	·8	2727	26·957	·8	104	29·803
·9	5340	24·391	·9	2674	27·012	·9	52	29·862
202·0	5286	24·442	207·0	2622	27·066	212·0	0	29·922
·1	5232	24·492	·1	2569	27·121	·1	− 52	29·981
·2	5178	24·542	·2	2516	27·179	·2	− 104	30·041
·3	5124	24·593	·3	2464	27·231	·3	− 155	30·101
·4	5070	24·644	·4	2411	27·286	·4	− 207	30·161
·5	5017	24·694	·5	2358	27·341	·5	− 259	30·221
·6	4964	24·745	·6	2305	27·397	·6	− 311	30·281
·7	4910	24·796	·7	2252	27·452	·7	− 363	30·341
·8	4856	24·847	·8	2199	27·507	·8	− 414	30·401
·9	4802	24·898	·9	2146	27·563	·9	− 466	30·461
203·0	4749	24·949	208·0	2094	27·618	213·0	− 518	30·522
·1	4695	25·000	·1	2041	27·674	·1	− 570	30·583
·2	4641	25·051	·2	1989	27·730	·2	− 621	30·644
·3	4588	25·103	·3	1936	27·786	·3	− 673	30·705
·4	4535	25·154	·4	1884	27·842	·4	− 724	30·766
·5	4482	25·206	·5	1831	27·898	·5	− 776	30·827
·6	4428	25·257	·6	1778	27·954	·6	− 828	30·888
·7	4375	25·309	·7	1726	28·011	·7	− 880	30·949
·8	4322	25·361	·8	1673	28·067	·8	− 932	31·010
·9	4268	25·413	·9	1621	28·123	·9	− 983	31·071
204·0	4215	25·465	209·0	1568	28·180	214·0	−1035	31·132
·1	4161	25·517	·1	1516	28·237	·1	−1086	31·194
·2	4107	25·569	·2	1463	28·293	·2	−1138	31·256
·3	4053	25·621	·3	1411	28·350	·3	−1189	31·318
·4	4000	25·674	·4	1358	28·407	·4	−1241	31·380
·5	3947	25·726	·5	1306	28·464	·5	−1293	31·442
·6	3894	25·779	·6	1254	28·521	·6	−1344	31·504
·7	3841	25·831	·7	1201	28·579	·7	−1396	31·566
·8	3788	25·884	·8	1149	28·636	·8	−1447	31·628
·9	3735	25·937	·9	1096	28·693	·9	−1549	31·690

TABLE XI.

Correction for Temperature of Intermediate Air to be Used in the Determination of Heights by Boiling Point Thermometer and Barometer.

Mean temperature of intermediate air.	Multiplier.	Mean temperature of intermediate air.	Multiplier.	Mean temperature of intermediate air.	Multiplier.	Mean temperature of intermediate air.	Multiplier.
°		°		°		°	
20	0·9734	37	1·0111	54	1·0488	70	1·0844
21	0·9756	38	1·0133	55	1·0511	71	1·0866
22	0·9778	39	1·0155	56	1·0533	72	1·0888
23	0·9801	40	1·0177	57	1·0555	73	1·0911
24	0·9823	41	1·0199	58	1·0577	74	1·0933
25	0·9845	42	1·0222	59	1·0599	75	1·0955
26	0·9867	43	1·0244	60	1·0622	76	1·0977
27	0·9889	44	1·0266	61	1·0644	77	1·0999
28	0·9912	45	1·0288	62	1·0666	78	1·1022
29	0·9934	46	1·0311	63	1·0688	79	1·1044
30	0·9956	47	1·0333	64	1·0711	80	1·1066
31	0·9978	48	1·0355	65	1·0733	81	1·1088
32	1·0000	49	1·0377	66	1·0755	82	1·1111
33	1·0022	50	1·0399	67	1·0777	83	1·1133
34	1·0044	51	1·0422	68	1·0799	84	1·1156
35	1·0066	52	1·0444	69	1·0822	85	1·1178
36	1·0088	53	1·0466				

TABLE XII.

Determination of Height by Mercurial Barometer and Aneroid.

PART I.—Argument, the observed Height of the Barometer at either Station.

Inches.	Feet.	Diff.	Inches.	Feet.	Diff.	Inches.	Feet.	Diff.	Inches.	Feet.	Diff.
11·0	1396·9	236·4	16·0	11186·3	162·8	21·0	18291·0	124·1	26·0	23871·0	100·3
11·1	1633·3	234·3	16·1	11349·1	161·8	21·1	18415·1	123·6	26·1	23971·3	99·9
11·2	1867·6	232·3	16·2	11510·9	160·8	21·2	18538·7	122·9	26·2	24071·2	99·5
11·3	2099·9	230·2	16·3	11671·7	159·8	21·3	18661·6	122·4	26·3	24170·7	99·1
11·4	2330·1	228·2	16·4	11831·5	158·8	21·4	18784·0	121·8	26·4	24269·8	98·8
11·5	2558·3	226·2	16·5	11990·3	157·9	21·5	18905·8	121·2	26·5	24368·6	98·4
11·6	2784·5	224·2	16·6	12148·2	156·9	21·6	19027·0	120·7	26·6	24467·0	98·1
11·7	3008·7	222·4	16·7	12305·1	155·9	21·7	19147·7	120·1	26·7	24565·1	97·6
11·8	3231·1	220·5	16·8	12461·0	155·1	21·8	19267·8	119·6	26·8	24662·7	97·3
11·9	3451·6	218·6	16·9	12616·1	154·1	21·9	19387·4	119·0	26·9	24760·0	97·0
12·0	3670·2	216·8	17·0	12770·2	153·3	22·0	19506·4	118·5	27·0	24857·0	96·6
12·1	3887·0	215·0	17·1	12923·5	152·3	22·1	19624·9	118·0	27·1	24953·6	96·2
12·2	4102·0	213·3	17·2	13075·8	151·5	22·2	19742·9	117·4	27·2	25049·8	95·9
12·3	4315·3	211·6	17·3	13227·3	150·6	22·3	19860·3	116·9	27·3	25145·7	95·5
12·4	4526·9	209·8	17·4	13377·9	149·7	22·4	19977·2	116·4	27·4	25241·2	95·2
12·5	4736·7	208·2	17·5	13527·6	148·9	22·5	20093·6	115·8	27·5	25336·4	94·8
12·6	4944·9	206·5	17·6	13676·5	148·0	22·6	20209·4	115·4	27·6	25431·2	94·5
12·7	5151·4	205·0	17·7	13824·5	147·2	22·7	20324·8	114·8	27·7	25525·7	94·2
12·8	5356·4	203·3	17·8	13971·7	146·3	22·8	20439·6	114·4	27·8	25619·9	93·8
12·9	5559·7	201·7	17·9	14118·0	145·6	22·9	20554·0	113·8	27·9	25713·7	93·4
13·0	5761·4	200·2	18·0	14263·6	144·7	23·0	20667·8	113·3	28·0	25807·1	93·2
13·1	5961·6	198·7	18·1	14408·3	144·0	23·1	20781·1	112·9	28·1	25900·3	92·8
13·2	6160·3	197·2	18·2	14552·3	143·1	23·2	20894·0	112·4	28·2	25993·1	92·5
13·3	6357·5	195·7	18·3	14695·4	142·4	23·3	21006·4	111·9	28·3	26085·6	92·1
13·4	6553·2	194·3	18·4	14837·8	141·6	23·4	21118·3	111·4	28·4	26177·7	91·9
13·5	6747·5	192·8	18·5	14979·4	140·9	23·5	21229·7	110·9	28·5	26269·6	91·5
13·6	6940·3	191·4	18·6	15120·3	140·0	23·6	21340·6	110·5	28·6	26361·1	91·2
13·7	7131·7	190·0	18·7	15260·3	139·4	23·7	21451·1	110·0	28·7	26452·3	90·9
13·8	7321·7	188·6	18·8	15399·7	138·6	23·8	21561·1	109·5	28·8	26543·2	90·5
13·9	7510·3	187·3	18·9	15538·3	137·9	23·9	21670·6	109·1	28·9	26633·7	90·3
14·0	7697·6	186·0	19·0	15676·2	137·1	24·0	21779·7	108·7	29·0	26724·0	89·9
14·1	7883·6	184·6	19·1	15813·3	136·5	24·1	21888·4	108·2	29·1	26813·9	89·6
14·2	8068·2	183·3	19·2	15949·8	135·7	24·2	21996·6	107·7	29·2	26903·5	89·3
14·3	8251·5	182·1	19·3	16085·5	135·0	24·3	22104·3	107·3	29·3	26992·8	89·1
14·4	8433·6	180·8	19·4	16220·5	134·3	24·4	22211·6	106·8	29·4	27081·9	88·7
14·5	8614·4	179·6	19·5	16354·8	133·7	24·5	22318·4	106·4	29·5	27170·6	88·4
14·6	8794·0	178·3	19·6	16488·5	132·9	24·6	22424·8	106·0	29·6	27259·0	88·1
14·7	8972·3	177·2	19·7	16621·4	132·3	24·7	22530·8	105·6	29·7	27347·1	87·8
14·8	9149·5	176·0	19·8	16753·7	131·6	24·8	22636·4	105·1	29·8	27434·9	87·6
14·9	9325·5	174·8	19·9	16885·3	131·0	24·9	22741·5	104·8	29·9	27522·5	87·2
15·0	9500·3	173·5	20·0	17016·3	130·3	25·0	22846·3	104·3	30·0	27609·7	86·9
15·1	9673·8	172·4	20·1	17146·6	129·7	25·1	22950·6	103·8	30·1	27696·6	86·7
15·2	9846·2	171·3	20·2	17276·3	129·0	25·2	23054·4	103·5	30·2	27783·3	86·4
15·3	10017·5	170·2	20·3	17405·3	128·4	25·3	23157·9	103·1	30·3	27869·7	86·0
15·4	10187·7	169·1	20·4	17533·7	127·7	25·4	23261·0	102·6	30·4	27955·7	85·8
15·5	10356·8	168·0	20·5	17661·4	127·2	25·5	23363·6	102·3	30·5	28041·5	85·6
15·6	10524·8	167·0	20·6	17788·6	126·5	25·6	23465·9	101·8	30·6	28127·1	85·2
15·7	10691·8	165·9	20·7	17915·1	125·9	25·7	23567·7	101·5	30·7	28212·3	85·0
15·8	10857·7	164·8	20·8	18041·0	125·3	25·8	23669·2	101·1	30·8	28297·3	84·7
15·9	11022·5	163·8	20·9	18166·3	124·7	25·9	23770·3	100·7	30·9	28382·0	84·4
16·0	11186·3		21·0	18291·0		26·0	23871·0		31·0	28466·4	

TABLE XII.—(*continued.*)

DETERMINATION OF HEIGHT BY MERCURIAL BAROMETER AND ANEROID.

PART II.—CORRECTION DUE TO T—T', OR THE DIFFERENCE OF THE TEMPERATURES OF THE BAROMETERS THEMSELVES (NOT FOR THAT OF THE INTERMEDIATE AIR) AT THE TWO STATIONS.

This Correction is Negative when the Temperature at the upper station is lowest, and vice versâ.

T—T'.	Correction.	T—T'.	Correction.	T—T'.	Correction.	T—T'.	Correction.	T—T'.	Correction.	T—T'.	Correction.
Fahr.	Feet.	Fahr.	Feet.	Fahr.	Feet.	Fahr.	Feet.	Fahr.	Feet.	Fahr.	Feet.
°		°		°		°		°		°	
1	2.3	14	32.8	27	63.2	40	93.6	53	124.1	66	154.5
2	4.7	15	35.1	28	65.5	41	96.0	54	126.4	67	156.8
3	7.0	16	37.5	29	67.9	42	98.3	55	128.7	68	159.2
4	9.4	17	39.8	30	70.2	43	100.7	56	131.1	69	161.5
5	11.7	18	42.1	31	72.6	44	103.0	57	133.4	70	163.9
6	14.0	19	44.5	32	74.9	45	105.3	58	135.8	71	166.2
7	16.4	20	46.8	33	77.3	46	107.7	59	138.1	72	168.6
8	18.7	21	49.2	34	79.6	47	110.0	60	140.4	73	170.9
9	21.1	22	51.5	35	81.9	48	112.4	61	142.8	74	173.3
10	23.4	23	53.8	36	84.3	49	114.7	62	145.1	75	175.6
11	25.8	24	56.2	37	86.6	50	117.0	63	147.5	76	177.9
12	28.1	25	58.5	38	89.0	51	119.4	64	149.8	77	180.3
13	30.4	26	60.9	39	91.3	52	121.7	65	152.2	78	182.6

PART III. CORRECTION DUE TO THE CHANGE OF GRAVITY FROM THE LATITUDE OF 45° TO THE LATITUDE OF THE PLACE OF OBSERVATION. *Positive from Lat. 0° to 45°; Negative from Lat. 45° to 90°.*

PART IV. CORRECTION FOR DECREASE OF GRAVITY ON A VERTICAL. *Always Positive.*

PART V. CORRECTION DUE TO THE HEIGHT OF THE LOWER STATION. *Always Positive.*

App. Alt.	Part III. Latitude. 0° / 90°	10° / 80°	20° / 70°	30° / 60°	40° / 50°	45°	Part IV.	Part V. Height of Barometer at Lower Station. 16 in.	18 in.	20 in.	22 in.	24 in.	26 in.	28 in.	App. Alt.
Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
1000	2.6	2.5	2.0	1.3	0.5	0	2.5	1.6	1.3	1.0	0.8	0.6	0.4	0.2	1000
2000	5.3	5.0	4.1	2.6	0.9	0	5.2	3.1	2.5	2.0	1.5	1.1	0.7	0.3	2000
3000	7.9	7.5	6.1	4.0	1.4	0	7.9	4.7	3.8	3.0	2.3	1.7	1.1	0.5	3000
4000	10.6	10.0	8.1	5.3	1.8	0	10.8	6.3	5.1	4.0	3.1	2.2	1.4	0.7	4000
5000	13.2	12.4	10.1	6.6	2.3	0	13.7	7.8	6.4	5.0	3.8	2.8	1.8	0.8	5000
6000	15.9	14.9	12.2	7.9	2.8	0	16.7	9.4	7.6	6.0	4.6	3.3	2.1	1.0	6000
7000	18.5	17.4	14.2	9.3	3.2	0	19.9	11.0	8.9	7.1	5.4	3.9	2.5	1.2	7000
8000	21.2	19.9	16.2	10.6	3.7	0	23.1	12.5	10.2	8.1	6.2	4.4	2.8	1.3	8000
9000	23.8	22.4	18.3	11.9	4.1	0	26.4	14.1	11.4	9.1	6.9	5.0	3.2	1.5	9000
10000	26.5	24.9	20.3	13.2	4.6	0	29.8	15.7	12.7	10.1	7.7	5.5	3.5	1.7	10000
11000	29.1	27.4	22.3	14.6	5.1	0	33.3	17.2	14.0	11.1	8.5	6.1	3.9	1.8	11000
12000	31.8	29.9	24.4	15.9	5.5	0	36.9	18.8	15.3	12.1	9.2	6.6	4.2	2.0	12000
13000	34.4	32.4	26.4	17.2	6.0	0	40.6	20.4	16.5	13.1	10.0	7.2	4.6	2.2	13000
14000	37.1	34.9	28.4	18.5	6.4	0	44.4	21.9	17.8	14.1	10.8	7.7	4.9	2.3	14000
15000	39.7	37.3	30.4	19.9	6.9	0	48.3	23.5	19.1	15.1	11.5	8.3	5.3	2.5	15000
16000	42.4	39.8	32.5	21.2	7.4	0	52.3	25.1	20.3	16.1	12.3	8.8	5.6	2.7	16000
17000	45.0	42.3	34.5	22.5	7.8	0	56.4	26.6	21.6	17.1	13.1	9.4	6.0	2.8	17000
18000	47.7	44.8	36.5	23.8	8.3	0	60.5	28.2	22.9	18.1	13.8	9.9	6.3	3.0	18000
19000	50.3	47.3	38.6	25.2	8.7	0	64.8	29.8	24.1	19.2	14.6	10.5	6.7	3.2	19000
20000	53.0	49.8	40.6	26.5	9.2	0	69.2	31.3	25.4	20.2	15.4	11.0	7.0	3.3	20000
21000	55.6	52.3	42.6	27.8	9.7	0	73.6	32.9	26.7	21.2	16.1	11.6	7.4	3.5	21000
22000	58.3	54.8	44.7	29.1	10.1	0	78.2	34.5	28.0	22.2	16.9	12.1	7.7	3.7	22000
23000	60.9	57.3	46.7	30.5	10.6	0	82.9	36.0	29.2	23.2	17.7	12.7	8.1	3.8	23000
24000	63.6	59.8	48.7	31.8	11.0	0	87.6	37.6	30.5	24.2	18.5	13.2	8.4	4.0	24000
25000	66.2	62.2	50.7	33.1	11.5	0	92.5	39.1	31.8	25.2	19.2	13.8	8.8	4.1	25000

TABLE XIII.

Logarithms for Facilitating the Computation of Terrestrial Latitudes, Longitudes, and Reverse Azimuths.

Lat.	P		Q		R		S		T	
	$\frac{1}{\rho \sin 1''}$		$\frac{\rho}{\nu}$		$\frac{1}{2\rho}$		$2 \sec \lambda \frac{\rho}{\nu}$		$\left(2 \tan^2 \lambda + \frac{\nu}{\rho}\right) \times \left(\frac{\cot \lambda \cos \lambda}{2}\right)$	
° ′		Diff. −		Diff. +		Diff. −		Diff. +		Diff. −
0 0	$\bar{3}$·9966885	1	$\bar{1}$·9970432	0	$\bar{8}$·38123	0	0·29807	0	Infinite.	Infin.
0 10	6884	1	0432	1	23	0	807	1	2·23820	30101
0 20	6883	2	0433	1	23	0	808	1	1·93719	17607
0 30	6881	2	0434	2	23	0	809	1	76112	12491
0 40	6879	4	0436	2	23	0	810	2	63621	9687
0 50	6875	4	0438	3	23	0	812	2	53934	7914
1 0	$\bar{3}$·9966871	5	$\bar{1}$·9970441	3	$\bar{8}$·38123	0	0·29814	2	1·46020	6689
1 10	6866	5	0444	4	23	0	16	3	39331	5793
1 20	6861	6	0448	4	23	0	19	3	33538	5108
1 30	6855	8	0452	5	23	0	22	4	28430	4568
1 40	6847	7	0457	5	23	0	26	4	23862	4130
1 50	6840	9	0462	6	23	0	30	4	19732	3769
2 0	$\bar{3}$·9966831	9	$\bar{1}$·9970468	6	$\bar{8}$·38123	0	0·29834	5	1·15963	3466
2 10	6822	10	0474	7	23	0	39	5	12497	3207
2 20	6812	11	0481	7	23	0	44	5	09290	2984
2 30	6801	12	0488	8	23	1	49	6	06306	2790
2 40	6789	12	0496	8	22	0	55	6	03516	2619
2 50	6777	13	0504	9	22	0	61	7	00897	2468
3 0	$\bar{3}$·9966764	14	$\bar{1}$·9970513	9	$\bar{8}$·38122	0	0·29868	7	0·98429	2333
3 10	6750	15	0522	10	22	0	75	7	96096	2211
3 20	6735	15	0532	10	22	0	82	7	93885	2102
3 30	6720	16	0542	10	22	0	89	9	91783	2002
3 40	6704	17	0552	12	22	1	98	8	89781	1912
3 50	6687	17	0564	11	21	0	0·29906	9	87869	1828
4 0	$\bar{3}$·9966670	19	$\bar{1}$·9970575	13	$\bar{8}$·38121	0	0·29915	9	0·86041	1752
4 10	6651	19	0588	12	21	0	24	9	84289	1683
4 20	6632	19	0600	13	21	0	33	10	82606	1617
4 30	6613	21	0613	14	21	1	43	10	80989	1556
4 40	6592	21	0627	14	20	0	53	11	79433	1500
4 50	6571	22	0641	15	20	0	64	11	77933	1448
5 0	$\bar{3}$·9966549	23	$\bar{1}$·9970656	15	$\bar{8}$.38120	0	0·29975	12	0·76485	1399
5 10	6526	23	0671	16	20	0	87	11	75086	1352
5 20	6503	24	0687	16	20	1	98	12	73734	1309
5 30	6479	25	0703	16	19	0	0·30010	13	72425	1269
5 40	6454	26	0719	17	19	0	23	13	71156	1230
5 50	6428	26	0736	18	19	0	36	13	69926	1194

TABLE XIII.—(*continued*).

·Logarithms for Facilitating the Computation of Terrestrial Latitudes, Longitudes, and Reverse Azimuths.

Lat.	P		Q		R		S		T	
° ′		Diff. −		Diff. +		Diff. −		Diff. +		Diff. −
6 0	$\bar{3}$·9966402	27	$\bar{1}$·9970754	18	$\bar{8}$·38119	1	0·30049	14	0·68732	1160
6 10	6375	28	0772	19	18	0	63	14	67572	1127
6 20	6347	29	0791	19	18	0	77	14	66445	1096
6 30	6318	29	0810	19	18	1	91	15	65349	1067
6 40	6289	30	0829	20	17	0	0·30106	15	64282	1039
6 50	6259	31	0849	21	17	0	21	16	63243	1013
7 0	$\bar{3}$·9966228	31	$\bar{1}$·9970870	21	$\bar{8}$·38117	1	0·30137	16	0·62230	986
7 10	6197	32	0891	21	16	0	53	16	61244	963
7 20	6165	33	0912	22	16	0	69	16	60281	939
7 30	6132	34	0934	23	16	1	85	18	59342	917
7 40	6098	34	0957	22	15	0	0·30203	17	58425	896
7 50	6064	35	0979	24	15	0	20	18	57529	875
8 0	$\bar{3}$·9966029	36	$\bar{1}$·9971003	24	$\bar{8}$·38115	1	0·30238	18	0·56654	856
8 10	5993	37	1027	24	14	0	56	18	55798	837
8 20	5956	37	1051	25	14	0	74	19	54961	819
8 30	5919	38	1076	25	14	1	93	20	54142	801
8 40	5881	39	1101	26	13	0	0·30313	19	53341	784
8 50	5842	39	1127	26	13	0	32	21	52557	769
9 0	$\bar{3}$·9965803	40	$\bar{1}$·9971153	27	$\bar{8}$·38113	1	0·30353	20	0·51788	752
9 10	5763	41	1180	27	12	0	373	21	51036	737
9 20	5722	41	1207	28	12	1	394	21	50299	723
9 30	5681	43	1235	28	11	0	415	22	49576	709
9 40	5638	43	1263	29	11	1	437	22	48867	695
9 50	5595	43	1292	29	10	0	459	22	48172	682
10 0	$\bar{3}$·9965552	45	$\bar{1}$·9971321	29	$\bar{8}$·38110	0	0·30481	23	0·47490	669
10 10	5507	45	1350	30	10	1	504	23	46821	656
10 20	5462	45	1380	31	09	0	527	23	46165	645
10 30	5417	47	1411	31	09	1	550	24	45520	633
10 40	5370	47	1442	31	08	0	574	25	44887	621
10 50	5323	48	1473	32	08	1	599	24	44266	611
11 0	$\bar{3}$·9965275	48	$\bar{1}$·9971505	32	$\bar{8}$·38107	0	0·30623	25	0·43655	600
11 10	5227	49	1537	33	07	1	648	26	43055	589
11 20	5178	50	1570	33	06	0	674	26	42466	579
11 30	5128	51	1603	34	06	1	700	26	41887	570
11 40	5077	51	1637	34	05	0	726	27	41317	560
11 50	5026	52	1671	35	05	1	753	27	40757	550
12 0	$\bar{3}$·9964974	53	$\bar{1}$·9971706	35	$\bar{8}$·38104	0	0·30780	27	0·40207	542
12 10	4921	53	1741	36	04	1	807	28	39665	532
12 20	4868	54	1777	36	03	0	835	28	39133	524
12 30	4814	55	1813	36	03	1	863	29	38609	516
12 40	4759	55	1849	37	02	0	892	28	38093	507
12 50	4704	56	1886	37	02	1	920	30	37586	500

TABLE XIII.—(*continued*).

Logarithms for Facilitating the Computation of Terrestrial Latitudes, Longitudes, and Reverse Azimuths.

Lat.	P	Diff.	Q	Diff.	R	Diff.	S	Diff.	T	Diff.
° ′		−		+		−		+		−
	—		—		—					
13 0	3·9964648	57	1·9971923	38	8·38101	1	0·30950	30	0·37086	492
13 10	4591	57	1961	39	00	0	980	30	36954	484
13 20	4534	58	2000	38	— 00	1	0·31010	30	36110	477
13 30	4476	59	2038	39	8·38099	0	040	31	35633	469
13 40	4417	60	2077	40	99	1	071	31	35164	462
13 50	4357		2117		98		102		34702	
	—	60	—	40	—	1		32		455
14 0	3·9964297	60	1·9972157	40	8·38097	0	0·31134	32	0·34247	448
14 10	4237	62	2197	41	97	1	166	33	33799	442
14 20	4175	62	2238	42	96	0	199	33	33357	435
14 30	4113	62	2280	41	96	1	232	33	32922	429
14 40	4051	64	2321	43	95	1	265	34	32493	422
14 50	3987		2364		94		299		32071	
	—	64	—	42	—	0		34		416
15 0	3·9963923	64	1·9972406	44	8·38094	1	0·31333	34	0·31655	410
15 10	3859	66	2450	43	93	1	367	35	31245	404
15 20	3793	66	2493	44	92	0	402	35	30841	399
15 30	3727	66	2537	44	92	1	437	36	30442	393
15 40	3661	67	2581	45	91	1	473	36	30049	388
15 50	3594		2626		90		509		29661	
	—	68	—	45	—	0		37		383
16 0	3·9963526	69	1·9972671	46	8·38090	1	0·31546	36	0·29278	377
16 10	3457	69	2717	46	89	1	582	38	28901	371
16 20	3388	70	2763	47	88	0	620	37	28530	367
16 30	3318	70	2810	46	88	1	657	38	28163	361
16 40	3248	71	2856	48	87	1	695	39	27802	357
16 50	3177		2904		86		734		27445	
	—	72	—	48	—	0		39		351
17 0	3·9963105	72	1·9972952	48	8·38086	1	0·31773	39	0·27094	347
17 10	3033	73	3000	48	85	1	812	40	26747	342
17 20	2960	73	3048	49	84	1	852	40	26405	338
17 30	2887	74	3097	50	83	0	892	41	26067	333
17 40	2813	75	3147	50	83	1	933	40	25734	329
17 50	2738		3197		82		973		25405	
	—	75	—	50	—	1		42		324
18 0	3·9962663	76	1·9973247	50	8·38081	1	0·32015	42	0·25081	320
18 10	2587	77	3297	51	80	0	057	42	24761	316
18 20	2510	77	3348	52	80	1	099	42	24445	312
18 30	2433	78	3400	52	79	1	141	43	24133	307
18 40	2355	78	3452	52	78	1	184	44	23826	304
18 50	2277		3504		77		228		23522	
	—	79	—	52	—	1		44		300
19 0	3·9962198	80	1·9973556	54	8·38076	0	0·32272	44	0·23222	295
19 10	2118	80	3610	53	76	1	316	44	22927	292
19 20	2038	80	3663	54	75	1	360	45	22635	289
19 30	1958	82	3717	54	74	1	405	46	22346	284
19 40	1876	81	3771	55	73	1	451	46	22062	281
19 50	1795	83	3826	54	72	0	497	46	21781	278

TABLE XIII.—(*continued*).

Logarithms for Facilitating the Computation of Terrestrial Latitudes, Longitudes, and Reverse Azimuths.

Lat.	P	Diff. −	Q	Diff. +	R	Diff. −	S	Diff. +	T	Diff. −
° ′										
	—		—		—					
20 0	3·9961712	83	1·9973880	56	8·38072	1	0·32543	47	0·21503	273
20 10	1629	83	3936	56	71	1	590	47	21230	271
20 20	1546	85	3992	56	70	1	637	48	20959	267
20 30	1461	84	4048	56	69	1	685	48	20692	263
20 40	1377	86	4104	57	68	1	733	48	20429	261
20 50	1291	85	4161	57	67	0	781	49	20168	257
	—		—		—					
21 0	3·9961206	87	1·9974218	58	8·38067	1	0·32830	49	0·19911	253
21 10	1119	87	4276	58	66	1	879	50	19658	251
21 20	1032	87	4334	58	65	1	929	50	19407	248
21 30	0945	88	4392	59	64	1	979	51	19159	244
21 40	0857	89	4451	59	63	1	0·33030	51	18915	242
21 50	0768	89	4510	59	62	1	081	51	18673	239
	—		—		—					
22 0	3·9960679	90	1·9974569	60	8·38061	1	0·33132	52	0·18434	235
22 10	0589	90	4629	60	60	0	184	52	18199	233
22 20	0499	91	4689	61	60	1	236	53	17966	230
22 30	0408	91	4750	60	59	1	289	53	17736	226
22 40	0317	92	4810	62	58	1	342	54	17510	225
22 50	0225	92	4872	61	57	1	396	54	17285	221
	—		—		—					
23 0	3·9960133	93	1·9974933	62	8·38056	1	0·33450	54	0·17064	219
23 10	0040	93	4995	62	55	1	504	55	16845	216
	—									
23 20	3·9959947	94	5057	63	54	1	559	55	16629	213
21 30	9853	94	5120	63	53	1	614	56	16416	211
23 40	9759	95	5183	63	52	1	670	56	16205	208
23 50	9664	96	5246	64	51	1	726	57	15997	205
	—		—		—					
24 0	3·9959568	96	1·9975310	64	8·38050	1	0·33783	57	0·15792	204
24 10	9472	96	5374	64	49	1	840	58	15588	200
24 20	9376	97	5438	64	48	1	898	58	15388	199
24 30	9279	97	5502	65	47	1	956	58	15189	195
24 40	9182	98	5567	66	46	1	0·34014	59	14994	194
24 50	9084	99	5633	65	45	1	073	59	14800	191
	—		—		—					
25 0	3·9958985	98	1·5975698	66	8·38044	1	0·34132	60	0·14609	189
25 10	8887	100	5764	66	43	1	192	60	14420	187
25 20	8787	100	5830	67	42	1	252	61	14233	184
25 30	8687	100	5897	67	41	1	313	61	14049	182
25 40	8587	101	5964	67	40	1	374	62	13867	180
25 50	8486	101	6031	67	39	1	436	62	13687	178
	—		—		—					
26 0	3·9958385	102	1·9976098	68	8·38038	1	0·34498	62	0·13509	175
26 10	8283	102	6166	68	37	1	560	63	13334	174
26 20	8181	102	6234	69	36	1	623	64	13160	172
26 30	8079	103	6303	68	35	1	687	64	12988	169
26 40	7976	104	6371	69	34	1	751	64	12819	167
25 50	7872	104	6440	70	33	1	815	65	12652	166

TABLE XIII.—(*continued*).

Logarithms for Facilitating the Computation of Terrestrial Latitudes, Longitudes, and Reverse Azimuths.

Lat. ° ′	P	Diff. −	Q	Diff. +	R	Diff. −	S	Diff. +	T	Diff. −
	—		—		—		—			
27 0	3·2957768	104	1·9976510	69	8·38032	1	0·34880	65	0·12486	163
27 10	7664	105	6579	70	31	1	945	66	12323	162
27 20	7559	105	6648	70	30	1	0·35011	66	12161	160
27 30	7454	106	6719	71	29	1	077	67	12001	158
27 40	7348	106	6790	71	28	1	144	67	11843	155
27 50	7242		6861		27		211		11688	
	—	107	—	71	—	1		68		154
28 0	3·9957135	107	1·9976932	71	8·38026	1	0·35279	68	0·11534	152
28 10	7028	107	7003	71	25	1	347	69	11382	151
28 20	6921	108	7074	72	24	1	416	69	11231	148
28 30	6813	108	7146	72	23	1	485	69	11083	147
28 40	6705	109	7218	73	22	2	554	70	10936	145
28 50	6596		7291		20		624		10791	
	—	109	—	73	—	1		71		143
29 0	3·9956487	109	1·9977364	72	8·38019	1	0·35695	71	0·10648	141
29 10	6378	110	7436	74	18	1	766	71	10507	140
29 20	6268	110	7510	73	17	1	837	72	10367	138
29 30	6158	111	7583	74	16	1	904	73	10229	137
29 40	6047	111	7657	74	15	1	982	73	10092	134
29 50	5936		7731		14		0·36055		09958	
	—	111	—	74	—	1		73		134
30 0	3·9955825	112	1·9977805	75	8·38013	1	0·36128	74	0·09824	131
30 10	5713	112	7880	74	12	1	202	74	09693	130
30 20	5601	112	7954	75	11	2	276	75	09563	129
30 30	5489	113	8029	76	09	1	351	76	09434	127
30 40	5376	113	8103	75	08	1	427	76	09307	125
30 50	5263		8180		07		503		09182	
	—	114	—	76	—	1		76		124
31 0	3·9955149	114	1·9978256	76	8·38006	1	0·36579	77	0·09058	123
31 10	5035	114	8332	76	05	1	656	77	08935	121
31 20	4921	115	8408	76	04	1	733	78	08814	119
31 30	4806	115	8484	77	03	2	811	79	08695	118
31 40	4691	115	8561	77	01	1	890	79	08577	117
31 50	4576		8638		00		969		08460	
	—	115	—	77	—	1		79		116
32 0	3·9954461	116	1·9978715	77	8·37999	1	0·37048	80	0·08344	114
32 10	4345	117	8792	78	98	1	128	81	08230	113
32 20	4228	116	8870	77	97	1	209	81	08117	111
32 30	4112	117	8947	78	96	2	290	81	08006	110
32 40	3995	117	9025	78	94	1	371	82	07896	108
32 50	3878		9103		93		453		07788	
	—	118	—	79	—	1		83		107
33 0	3·9953760	118	1·9979182	78	8·37992	1	0·37536	83	0·07681	106
33 10	3642	118	9 60	79	91	1	619	83	07575	105
33 20	3524	118	9339	79	90	1	702	85	07470	104
33 30	3406	119	9418	79	89	2	787	84	07366	102
33 40	3287	119	9497	80	87	1	871	85	07264	101
33 50	3168	119	9577	79	86	1	956	86	07163	99

TABLE XIII.—(*continued*).

Logarithms for Facilitating the Computation of Terrestrial Latitudes, Longitudes, and Reverse Azimuths.

Lat.	P		Q		R		S		T	
° ′		Diff.		Diff.		Diff.		Diff.		Diff.
	—	−	—	+	—	−		+		−
34 0	3·9953049	120	1·9979656	80	8·37985	1	0·38042	86	0·07064	99
34 10	2929	120	9736	80	84	1	128	87	06965	97
34 20	2809	120	9816	80	83	2	215	88	06868	96
34 30	2689	121	9896	80	81	1	303	87	06772	95
34 40	2568	120	— 9976	81	80	1	390	89	06677	94
34 50	2448		1·9980057		79		479		06583	
	—	121	—	80	—	1		89		93
35 0	3·9952327	121	1·9980137	81	8·37978	1	0·38568	89	0·06490	91
35 10	2206	122	0218	81	77	2	657	91	06399	91
35 20	2084	122	0299	81	75	1	748	90	06308	89
35 30	1962	122	0380	82	74	1	838	91	06219	88
35 40	1840	122	0462	81	73	1	929	92	06131	87
35 50	1718		0543		72		0·39021		06044	
	—	122	—	82	—	2		92		86
36 0	3·9951596	123	1·9980625	82	8·37970	1	0·39113	93	0·05958	85
36 10	1473	123	0707	82	69	1	206	94	05873	84
36 20	1350	123	0789	82	68	1	300	94	05789	83
36 30	1227	123	0871	82	67	1	394	94	05706	82
36 40	1104	124	0953	82	66	2	488	96	05624	81
36 50	0980		1035		64		584		05543	
	—	124	—	83	—	1		95		80
37 0	3·9950856	124	1·9981118	82	8·37963	1	0·39679	97	0·05463	79
37 10	0732	124	1200	83	62	1	776	96	05384	78
37 20	0608	124	1283	83	61	2	872	98	05306	77
37 30	0484	125	1366	83	59	1	970	98	05229	76
37 40	0359	125	1449	83	58	1	0·40068	99	05153	75
37 50	0234		1532		57		167		05078	
	—	125	—	84	—	1		99		75
38 0	3·9950109		1·9981616		8 37956		0·40266		0·05003	
	—	125		83		2		100		74
38 10	3·9949984	125	1699	84	54	1	366	100	04929	72
38 20	9859	126	1783	83	53	1	466	101	04857	71
38 30	9733	126	1866	84	52	1	567	102	04786	71
58 40	9607	125	1950	84	51	2	669	102	04715	70
38 50	9482		2034		49		771		04645	
	—	126	—	84	—	1		103		68
39 0	3·9949356	127	1·9982118	84	8·37948	1	0·40874	103	0·04577	68
39 10	9229	126	2202	85	47	1	977	104	04509	67
39 20	9103	126	2287	84	46	2	0·41081	105	04442	67
39 30	8977	127	2371	84	44	1	186	105	04375	65
39 40	8850	127	2455	85	43	1	291	106	04310	65
39 50	8723		2540		42		397		04245	
	—	127	—	84	—	2		107		63
40 0	3·9948596	127	1·9982624	85	8·37940	1	0·41504	107	0·04182	63
40 10	8469	127	2709	85	39	1	611	108	04119	62
40 20	8342	127	2794	85	38	1	719	108	04057	61
40 30	8215	128	2879	85	37	2	827	109	03996	61
40 40	8087	127	2964	85	35	1	936	110	03935	60
40 50	7960	128	3049	85	34	1	0·42046	110	03875	59

TABLE XIII.—(*continued*).

Logarithms for Facilitating the Computation of Terrestrial Latitudes, Longitudes, and Reverse Azimuths.

Lat.	P		Q		R		S		T	
° ′		Diff. −		Diff. +		Diff. −		Diff. +		Diff. −
	—		—		—					
41 0	3·9947832	128	1·9983134	85	8·37933	1	0·42156	111	0·03816	59
41 10	7704	127	3219	85	32	2	267	112	03757	58
41 20	7577	128	3304	86	30	1	379	112	03699	57
41 30	7449	128	3390	85	29	1	491	113	03642	56
41 40	7321	129	3475	85	28	2	604	114	03586	55
41 50	7192		3560		26		718		03531	
	—	128	—	86	—	1		114		54
42 0	3·9947064	128	1·9983646	85	8·37925	1	0·42832	115	0·03477	54
42 10	6936	129	3731	86	24	2	947	116	03423	53
42 20	6807	128	3817	85	22	1	0·43063	116	03370	53
42 30	6679	128	3902	86	21	1	179	117	03317	52
42 40	6551	129	3988	86	20	1	296	118	03265	51
42 50	6422		4074		19		414		03214	
	—	129	—	86	—	2		118		50
43 0	3·9946293	128	1·9984160	85	8·37917	1	0·43532	119	0·03164	50
43 10	6165	129	4245	86	16	1	651	120	03114	49
43 20	6036	119	4331	86	15	1	771	120	03065	49
43 30	5907	129	4417	86	14	2	891	121	03016	48
43 40	5778	129	4503	86	12	1	0·44012	122	02968	47
43 50	5649		4589		11		134		02921	
	—	129	—	86	—	1		122		47
44 0	3·9945520	128	1·9984675	86	8·37910	2	0·44256	124	0·02874	46
44 10	5392	129	4761	86	08	1	380	123	02828	45
44 20	5263	129	4847	86	07	1	503	125	02783	45
44 30	5134	129	4933	86	06	1	628	125	02738	44
44 40	5005	129	5019	86	05	2	753	126	02694	44
44 50	4876		5105		03		879		02650	
	—	129	—	86	—	1		127		44
45 0	3·9944747	129	1·9985191	86	8 37902	1	0·45006	128	0·02606	43
45 10	4618	129	5277	86	01	2	134	128	02563	42
45 20	4489	129	5363	86	— 8·37899	1	262	129	02521	41
45 30	4360	129	5449	86	98	1	391	130	02480	40
45 40	4231	129	5535	86	97	2	521	131	02440	40
45 50	4102		5621		95		652		02400	
	—	129	—	86	—	1		131		39
46 0	3·9943973	129	1·9985707	86	8·37894	1	0·45783	132	0·02361	39
46 10	3844	129	5793	86	93	1	915	133	01322	39
46 20	3715	129	5879	86	92	2	0·46048	133	02283	38
46 30	3586	129	5965	85	90	1	181	135	02245	38
46 40	3457	129	6050	86	89	1	316	135	02207	37
46 50	3328		6136		88		451		02170	
	—	119	—	86	—	2		136		37
47 0	3·9943199	128	1·9986222	86	8·37886	1	0·46587	137	0·02133	36
47 10	3071	129	6308	86	85	1	724	137	02097	36
47 20	2942	128	6394	85	84	1	861	138	02061	35
47 30	2814	129	6479	86	83	2	999	140	02026	34
47 40	2685	128	6565	86	81	1	0·47139	140	01991	34
47 50	2557	129	6651	85	80	1	279	140	01958	33

TABLE XIII.—(*continued*).

Logarithms for Facilitating the Computation of Terrestrial Latitudes, Longitudes, and Reverse Azimuths.

Lat.	P		Q		R		S		T	
° ′	—	Diff. −	—	Diff. +	—	Diff. −		Diff. +		Diff. −
48 0	3·9942428	128	1·9986736	86	8·37879	2	0·47419	142	0·01925	33
48 10	2300	128	6822	85	77	1	561	142	01892	33
48 20	2172	129	6907	86	76	1	703	143	01859	32
48 30	2043	128	6993	85	75	1	846	145	01827	31
48 40	1915	128	7078	86	74	2	991	144	01796	31
48 50	1787		7164		72		0·48135		01765	
	—	127	—	85	—	1		146		30
49 0	3·9941660	128	1·9987249	85	8·37871	1	0·48281	147	0·01735	31
49 10	1532	128	7334	85	70	1	428	147	704	31
49 20	1404	127	7419	85	69	2	575	149	673	30
49 30	1277	128	7504	85	67	1	724	149	643	29
49 40	1149	127	7589	85	66	1	873	150	614	29
49 50	1022		7674		65		0·49023		585	
	—	127	—	85	—	2		151		29
50 0	3·9940895	127	1·9987759	85	8·37863	1	0·49174	152	0·01556	28
50 10	0768	127	7844	84	62	1	326	152	528	27
50 20	0641	127	7928	85	61	1	478	154	501	27
50 30	0514	127	8013	84	60	2	632	155	474	27
50 40	0387	126	8097	84	58	1	787	155	447	26
50 50	0261		8181		57		942		421	
	—	127	—	85	—	1		156		26
51 0	3·9940134	126	1·9988266	84	8·37856	1	0·50098	158	0·01395	26
51 10	0008		8350		55		256		369	
	—	126		84		2		158		25
51 20	3·9939882	126	8434	84	53	1	414	159	344	25
51 30	9756	126	8518	84	52	1	573	160	319	24
51 40	9630	125	8602	83	51	2	733	161	295	24
51 50	9505		8685		49		894		271	
	—	125	—	84	—	1		162		24
52 0	3·9939380	126	1·9988769	83	8·37848	1	0·51056	163	0·01247	24
52 10	9254	125	8852	84	47	1	219	164	223	23
52 20	9129	124	8936	83	46	1	383	165	200	23
52 30	9005	125	9019	83	45	2	548	166	177	22
52 40	8880	125	9102	83	43	1	714	167	155	22
52 50	8755		9185		42		881		133	
	—	124	—	83	—	1		168		21
53 0	3·9938631	124	1·9989268	82	8·37841	1	0·52049	169	0·01112	22
53 10	8507	124	9350	83	40	2	218	170	090	21
53 20	8383	123	9433	82	38	1	388	171	069	21
53 30	8260	124	9515	83	37	1	559	172	048	20
53 40	8136	123	9598	82	36	1	731	174	028	20
53 50	8013		9680		35		905		008	
	—	123	—	82	—	2		174		19
54 0	3·9937890	122	1·9989762	82	8·37833	1	0·53079	175	0·00989	20
54 10	7768	123	9844	81	31	1	254	176	969	19
54 20	7645	122	— 9925	82	31	1	430	178	950	19
54 30	7523	122	1·9990007	81	30	1	608	178	931	18
54 40	7401	122	0088	81	29	2	786	180	913	18
54 50	7279	121	0169	81	27	1	966	180	895	17

TABLE XIII.—(*continued*).

Logarithms for Facilitating the Computation of Terrestrial Latitudes, Longitudes, and Reverse Azimuths.

Lat.	P	Diff. −	Q	Diff. +	R	Diff. −	S	Diff. +	T	Diff. +
° ′										
55 0	3·9937158	122	1·9990250	81	8·37826	1	0·54146	182	0·00878	18
55 10	7036	121	0331	81	25	1	328	183	860	18
55 20	6915	120	0412	80	24	2	511	184	842	17
55 30	6795	121	0492	80	22	1	695	185	825	17
55 40	6674	120	0572	81	21	1	880	187	808	16
55 50	6554	120	0653	80	20	1	0·55067	187	792	16
56 0	3·9936434	120	1·9990733	79	8·37819	1	0·55254	189	0·00776	16
56 10	6314	119	0812	80	18	2	443	190	760	16
56 20	6195	119	0892	79	16	1	633	191	744	16
56 30	6076	119	0971	79	15	1	824	192	728	15
56 40	5957	118	1050	79	14	1	0·56016	193	713	15
56 50	5839	118	1129	79	13	1	209	195	698	14
57 0	3·9935721	118	1·9991208	79	8·37812	1	0·56404	196	0·00684	15
57 10	5603	118	1287	78	11	2	600	197	669	14
57 20	5485	117	1365	78	09	1	797	199	655	14
57 30	5368	117	1443	78	08	1	996	199	641	14
57 40	5251	117	1521	78	07	1	0·57195	201	627	13
57 50	5134	116	1599	78	06	1	396	203	614	13
58 0	3·9935018	116	1·9991677	77	8·37805	1	0·57599	203	0·00601	13
58 10	4902	116	1754	77	04	2	802	205	588	13
58 20	4786	115	1831	77	02	1	0·58007	207	575	13
58 30	4671	115	1908	76	01	1	214	207	562	12
58 40	4556	114	1984	77	00	1	421	209	550	12
58 50	4442	115	2061	76	8·37799	1	630	210	538	12
59 0	3·9934327	114	1·9992137	76	8·37798	1	0·58840	212	0·00526	12
59 10	4213	113	2213	76	97	1	0·59052	213	514	12
59 20	4100	113	2289	75	96	2	265	215	502	12
59 30	3897	113	2364	75	94	1	480	216	490	11
59 40	3874	113	2439	75	93	1	696	217	479	11
59 50	3761	112	2514	75	92	1	913	219	468	10
60 0	3·9933649		1·9992589		8·37791		0·60132		0·00458	

TABLE XIV.

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along the Meridian.

Formula : Length in feet $= \rho \sin 1''$.

Latitude.	Length in feet.	Logarithm.	Diff.	Latitude.	Length in feet.	Logarithm.	Diff.
° ′			+	° ′			+
0 0	100·7654	2·0033115	0	4 0	100·7704	2·0033330	9
0 5	7654	115	1	4 5	7706	339	9
0 10	7654	116	0	4 10	7708	348	9
0 15	7654	116	1	4 15	7710	357	10
0 20	7654	117	1	4 20	7713	367	10
0 25	7654	118	1	4 25	7715	377	10
0 30	7655	119	1	4 30	7717	387	10
0 35	7655	120	1	4 35	7719	397	11
0 40	7656	121	1	4 40	7722	408	10
0 45	7656	122	2	4 45	7724	418	11
0 50	7656	124	2	4 50	7727	429	11
0 55	7657	126	3	4 55	7729	440	11
1 0	100·7657	2·0033129	2	5 0	100·7732	2·0033451	11
1 5	7658	131	3	5 5	7735	462	12
1 10	7658	134	2	5 10	7737	474	11
1 15	7659	136	3	5 15	7740	485	12
1 20	7660	139	3	5 20	7743	497	12
1 25	7660	142	3	5 25	7745	509	12
1 30	7661	145	4	5 30	7748	521	12
1 35	7662	149	4	5 35	7751	533	13
1 40	7663	153	3	5 40	7754	546	13
1 45	7664	156	4	5 45	7757	559	13
1 50	7665	160	4	5 50	7660	572	13
1 55	7666	164	5	5 55	7763	585	13
2 0	100·7667	2·0033169	4	6 0	100·7766	2·0033598	13
2 5	7668	173	5	6 5	7769	611	14
2 10	7669	178	5	6 10	7772	625	14
2 15	7670	183	5	6 15	7776	639	14
2 20	7671	188	5	6 20	7779	653	14
2 25	7672	193	6	6 25	7782	667	15
2 30	7674	199	6	6 30	7786	682	14
2 35	7675	205	6	6 35	7789	696	15
2 40	7676	211	6	6 40	7792	711	15
2 45	7678	217	6	6 45	7796	726	15
2 50	7679	223	6	6 50	7799	741	15
2 55	7681	229	7	6 55	7803	756	16
3 0	100·7682	2·0033236	7	7 0	100·7806	2·0033772	15
3 5	7684	243	7	7 5	7810	787	16
3 10	7685	250	7	7 10	7814	803	16
3 15	7687	257	8	7 15	7817	819	16
3 20	7689	265	7	7 20	7821	835	16
3 25	7690	272	8	7 25	7825	851	17
3 30	7692	280	8	7 30	7829	868	17
3 35	7694	288	8	7 35	7833	885	17
3 40	7696	296	8	7 40	7837	902	17
3 45	7698	304	9	7 45	7841	919	17
3 50	7700	313	8	7 50	7845	936	17
3 55	7702	321	9	7 55	7849	953	18

TABLE XIV.—(*continued*).

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along the Meridian.

Latitude.		Length in feet.	Logarithm.	Diff.	Latitude.		Length in feet.	Logarithm.	Diff.
°	′			+	°	′			+
8	0	100·7853	2·0033971	18	12	0	100·8098	2·0035026	26
8	5	7857	989	18	12	5	8104	052	27
8	10	7861	2·0034007	18	12	10	8110	079	26
8	15	7865	025	19	12	15	8115	105	27
8	20	7870	044	18	12	20	8122	132	27
8	25	7874	062	19	12	25	8129	159	27
8	30	7878	081	19	12	30	8135	186	27
8	35	7883	100	19	12	35	8141	213	28
8	40	7887	119	19	12	40	8148	241	27
8	45	7892	138	19	12	45	8154	268	28
8	50	7896	157	20	12	50	8160	296	28
8	55	7901	177	20	12	55	8167	324	28
9	0	100·7905	2·0034197	20	13	0	100·8173	2·0035352	28
9	5	7910	217	20	13	5	8180	380	29
9	10	7914	237	20	13	10	8187	409	28
9	15	7919	257	21	13	15	8193	437	29
9	20	7924	278	20	13	20	8200	466	29
9	25	7929	298	21	13	25	8206	495	29
9	30	7934	319	21	13	30	8213	524	29
9	35	7939	340	22	13	35	8220	553	30
9	40	7944	362	21	13	40	8227	583	30
9	45	7949	383	22	13	45	8234	613	30
9	50	7953	405	21	13	50	8241	643	30
9	55	7959	426	22	13	55	8248	673	30
10	0	100·7964	2·0034448	22	14	0	100·8255	2·0035703	30
10	5	7969	470	22	14	5	8262	733	30
10	10	7974	492	22	14	10	8269	763	31
10	15	7979	514	23	14	15	8276	794	31
10	20	7984	537	23	14	20	8283	825	31
10	25	7990	560	23	14	25	8290	856	31
10	30	7995	583	23	14	30	8297	887	31
10	35	8000	606	24	14	35	8305	918	31
10	40	8006	630	23	14	40	8312	949	32
10	45	8011	653	24	14	45	8319	981	32
10	50	8017	677	24	14	50	8327	2·0036013	32
10	55	8022	701	24	14	55	8334	045	32
11	0	100·8028	2·0034725	24	15	0	100·8342	2·0036077	32
11	5	8034	749	24	15	5	8349	109	32
11	10	8039	773	24	15	10	8357	141	33
11	15	8045	797	25	15	15	8364	174	33
11	20	8050	822	25	15	20	8372	207	33
11	25	8056	847	25	15	25	8379	240	33
11	30	8062	872	25	15	30	8387	273	33
11	35	8068	897	26	15	35	8395	306	33
11	40	8074	923	25	15	40	8403	339	33
11	45	8080	948	26	15	45	8410	372	34
11	50	8086	974	26	15	50	8418	406	34
11	55	8092	2·0035000	26	15	55	8426	440	34

TABLE XIV.—(*continued*).

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along the Meridian.

Latitude.	Length in feet.	Logarithm.	Diff.	Latitude.	Length in feet.	Logarithm.	Diff.
° ′			+	° ′			+
16 0	100·8434	2·0036474	34	20 0	100·8855	2·0038288	41
16 5	8442	508	35	20 5	8865	329	42
16 10	8450	543	34	20 10	8874	371	41
16 15	8458	577	35	20 15	8884	412	42
16 20	8466	612	35	20 20	8894	454	42
16 25	8474	647	35	20 25	8903	496	42
16 30	8482	682	35	20 30	8913	538	42
16 35	8490	717	35	20 35	8923	580	43
16 40	8498	752	35	20 40	8933	623	42
16 45	8506	787	36	20 45	8943	665	43
16 50	8515	823	35	20 50	8953	708	43
16 55	8523	859	36	20 55	8963	751	43
17 0	100·8531	2·0036895	36	21 0	100·8973	2·0038794	43
17 5	8540	931	36	21 5	8983	837	44
17 10	8548	967	36	21 10	8993	881	43
17 15	8557	2·0037003	37	21 15	9003	924	44
17 20	8565	040	36	21 20	9013	968	43
17 25	8574	076	37	21 25	9023	2·0039011	44
17 30	8582	113	37	21 30	9033	055	44
17 35	8591	150	37	21 35	9043	099	44
17 40	8599	187	37	21 40	9054	143	44
17 45	8608	224	38	21 45	9064	187	45
17 50	8617	262	37	21 50	9074	232	44
17 55	8626	299	38	21 55	9085	276	45
18 0	100·8634	2·0037337	38	22 0	100·9095	2·0039321	45
18 5	8643	375	38	22 5	9106	366	45
18 10	8652	413	38	22 10	9116	411	45
18 15	8661	451	39	22 15	9127	456	45
18 20	8670	490	38	22 20	9137	501	45
18 25	8679	528	39	22 25	9147	546	46
18 30	8688	567	39	22 30	9158	592	45
18 35	8697	606	39	22 35	9169	637	46
18 40	8706	645	39	22 40	9179	683	46
18 45	8715	684	39	22 45	9190	729	46
18 50	8724	723	39	22 50	9200	775	46
18 55	8733	762	40	22 55	9211	821	46
19 0	100·8742	2·0037802	40	23 0	100·9222	2·0039867	46
19 5	8752	842	40	23 5	9233	913	47
19 10	8761	882	40	23 10	9244	960	46
19 15	8770	922	40	23 15	9254	2·0040006	47
19 20	8779	962	40	23 20	9265	053	47
19 25	8789	2·0038002	40	23 25	9276	100	47
19 30	8798	042	40	23 30	9287	147	47
19 35	8807	082	41	23 35	9298	194	47
19 40	8817	123	41	23 40	9309	241	47
19 45	8826	164	41	23 45	9320	288	48
19 50	8836	205	41	23 50	9331	336	48
19 55	8845	246	42	23 55	9342	384	48

TABLE XIV.—(*continued*).

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along the Meridian.

Latitude.	Length in feet.	Logarithm.	Diff.	Latitude.	Length in feet.	Logarithm.	Diff.
° ′			+	° ′			+
24 0	100·9353	2·0040432	48	28 0	100·9919	2·0042865	53
24 5	9364	480	48	28 5	9931	918	54
24 10	9375	528	48	28 10	9944	972	53
24 15	9387	576	48	28 15	9956	2·0043025	54
24 20	9398	624	48	28 20	99 9	079	54
24 25	9409	672	49	28 25	9981	133	54
24 30	9420	721	48	28 30	9994	187	54
24 35	9432	769	49	28 35	101·0006	241	54
24 40	9443	818	49	28 40	0019	295	54
24 45	9454	867	49	28 45	0031	349	54
24 50	9466	916	49	28 50	0044	403	54
24 55	9477	965	50	28 55	0056	457	55
25 0	100·9489	2·0041015	49	29 0	101·0069	2·0043512	55
25 5	9500	064	49	29 5	0082	567	55
25 10	9512	113	50	29 10	0095	622	55
25 15	9523	163	50	29 15	0107	677	55
25 20	9535	213	50	29 20	0120	732	55
25 25	9547	263	50	29 25	0133	787	55
25 30	9558	313	50	29 30	0146	842	55
25 35	9570	363	50	29 35	0159	897	55
25 40	9581	413	50	29 40	0172	952	55
25 45	9593	463	51	29 45	0185	2·0044007	56
25 50	9605	514	50	29 50	0198	063	56
25 55	9616	564	51	29 55	0210	119	56
26 0	100·9628	2·0041615	51	30 0	101·0223	2·0044175	56
26 5	9640	666	51	30 5	0236	231	56
26 10	9652	717	51	30 10	0249	287	56
26 15	9664	768	51	30 15	0262	343	56
26 20	9676	819	51	30 20	0275	399	56
26 25	9687	870	51	30 25	0289	455	56
26 30	9699	921	51	30 30	0302	511	56
26 35	9711	972	52	30 35	0315	567	57
26 40	9723	2·0042024	52	30 40	0328	624	56
26 45	9735	076	52	30 45	0341	680	57
26 50	9747	128	52	30 50	0354	737	57
26 55	9760	180	52	30 55	0367	794	57
27 0	100·9772	2·0042232	52	31 0	101·0381	2·0044851	57
27 5	9784	284	52	31 5	0394	908	57
27 10	9796	336	52	31 10	0407	965	57
27 15	9808	388	53	31 15	0421	2·0045022	57
27 20	9820	441	52	31 20	0434	079	57
27 25	9832	493	53	31 25	0447	136	57
27 30	9845	546	53	31 30	0461	193	57
27 35	9857	599	53	31 35	0474	250	58
27 40	9869	652	53	31 40	0487	308	58
27 45	9882	705	53	31 45	0501	366	58
27 50	9894	758	53	31 50	0514	424	57
27 55	9906	811	54	31 55	0527	481	58

TABLE XIV.—(*continued*).

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along the Meridian.

Latitude.	Length in feet.	Logarithm.	Diff.	Latitude.	Length in feet.	Logarithm.	Diff.
° ′			+	° ′			+
32 0	101·0541	2·0045539	58	36 0	101·1208	2·0048404	61
32 5	0554	597	58	36 5	1222	465	62
32 10	0568	655	58	36 10	1236	527	61
32 15	0581	713	59	36 15	1250	588	62
32 20	0595	772	58	36 20	1265	650	61
32 25	0608	830	58	36 25	1279	711	62
32 30	0622	888	58	36 30	1294	773	61
32 35	0635	946	59	36 35	1308	834	62
32 40	0649	2·0046005	58	36 40	1322	896	62
32 45	0663	063	59	36 45	1337	958	62
32 50	0677	122	59	36 50	1351	2·0049020	62
32 55	0690	181	59	36 55	1366	082	62
33 0	101·0704	2·0046240	59	37 0	101·1380	2·0049144	62
33 5	0718	299	59	37 5	1395	206	62
33 10	0731	358	59	37 10	1409	268	62
33 15	0745	417	59	37 15	1423	330	62
33 20	0759	476	59	37 20	1438	392	62
33 25	0773	535	59	37 25	1452	454	62
33 30	0787	594	59	37 30	1467	516	62
33 35	0800	653	60	37 35	1481	578	63
33 40	0814	713	59	37 40	1496	641	62
33 45	0828	772	60	37 45	1510	703	63
33 50	0842	832	59	37 50	1525	766	62
33 55	0856	891	60	37 55	1539	828	63
34 0	101·0870	2·0046951	60	38 0	101·1554	2·0049891	62
34 5	0883	2·0047011	60	38 5	1569	953	63
34 10	0897	071	60	38 10	1583	2·0050016	62
34 15	0911	131	60	38 15	1598	078	63
34 20	0925	191	60	38 20	1612	141	63
34 25	0939	251	60	38 25	1627	204	63
34 30	0953	311	60	38 30	1642	267	62
34 35	0967	371	60	38 35	1656	329	63
34 40	0981	431	60	38 40	1671	392	63
34 45	0995	491	61	38 45	1686	455	63
34 50	1009	552	60	38 50	1700	518	63
34 55	1023	612	61	38 55	1715	581	63
35 0	101·1038	2·0047673	60	39 0	101·1730	2·0050644	63
35 5	1052	733	61	39 5	1744	707	64
35 10	1066	794	61	39 10	1759	771	63
35 15	1080	855	61	39 15	1774	834	63
35 20	1094	916	61	39 20	1788	897	63
35 25	1108	977	61	39 25	1803	960	63
35 30	1122	2·0048038	61	39 30	1818	2·0051023	63
35 35	1137	099	61	39 35	1832	086	64
35 40	1151	160	61	39 40	1847	150	63
35 45	1165	221	61	39 45	1862	213	64
35 50	1179	282	61	39 50	1877	277	63
35 55	1193	343	61	39 55	1891	340	64

TABLE XIV.—(*continued*).

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along the Meridian.

Latitude.	Length in feet.	Logarithm.	Diff.	Latitude.	Length in feet.	Logarithm.	Diff.
° ′			+	° ′			+
40 0	101·1906	2·0051404	63	44 0	101·2623	2·0054479	64
40 5	1921	467	64	44 5	2638	543	65
40 10	1936	531	63	44 10	2653	608	64
40 15	1951	594	64	44 15	2668	672	65
40 20	1966	658	63	44 20	2684	737	64
40 25	1980	721	64	44 25	2699	801	65
40 30	1995	785	64	44 30	2714	866	64
40 35	2010	849	64	44 35	2729	930	65
40 40	2025	913	63	44 40	2744	995	64
40 45	2040	976	64	44 45	2759	2·0055059	65
40 50	2055	2·0052040	64	44 50	2774	124	64
40 55	2070	104	64	44 55	2789	188	65
41 0	101·2085	2·0052168	64	45 0	101·2804	2·0055253	64
41 5	2100	232	64	45 5	2819	317	65
41 10	2114	296	63	45 10	2834	382	64
41 15	2129	359	64	45 15	2849	446	65
41 20	2144	423	64	45 20	2864	511	64
41 25	2159	487	64	45 25	2879	575	65
41 30	2174	551	64	45 30	2894	640	64
41 35	2189	615	64	45 35	2909	704	65
41 40	2204	679	64	45 40	2924	769	64
41 45	2219	743	65	45 45	2939	833	65
41 50	2234	808	64	45 50	2954	898	64
41 55	2249	872	64	45 55	2969	962	65
42 0	101·2264	2·0052936	64	46 0	101·2984	2·0056027	64
42 5	2279	2·0053000	64	46 5	2999	091	65
42 10	2294	064	64	46 10	3015	156	64
42 15	2308	128	64	46 15	3030	220	65
42 20	2323	192	64	46 20	3045	285	64
42 25	2338	256	65	46 25	3060	349	65
42 30	2353	321	64	46 30	3075	414	64
42 35	2368	385	64	46 35	3090	478	65
42 40	2383	449	64	46 40	3105	543	64
42 45	2398	513	65	46 45	3120	607	65
42 50	2413	578	64	46 50	3135	672	64
42 55	2428	642	65	46 55	3150	736	64
43 0	101·2443	2·0053707	64	47 0	101·3165	2·0056800	64
43 5	2458	771	64	47 5	3180	864	65
43 10	2473	835	64	47 10	3195	929	64
43 15	2488	899	65	47 15	3210	993	65
43 20	2503	964	64	47 20	3225	2·0057058	64
43 25	2518	2·0054028	65	47 25	3240	122	64
43 30	2533	093	64	47 30	3255	186	64
43 35	2548	157	65	47 35	3270	250	65
43 40	2563	222	64	47 40	3285	315	64
43 45	2578	286	65	47 45	3300	379	64
43 50	2593	351	64	47 50	3315	443	64
43 55	2608	415	64	47 55	3330	507	65

TABLE XIV.—(*continued*).

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along the Meridian.

Latitude.	Length in feet.	Logarithm.	Diff.	Latitude.	Length in feet.	Logarithm.	Diff.
° ′			+	° ′			+
48 0	101·3345	2·0057572	64	52 0	101·4056	2·0060620	63
48 5	3360	636	64	52 5	4071	683	63
48 10	3375	700	64	52 10	4085	746	62
48 15	3390	764	64	52 15	4100	808	63
48 20	3405	828	64	52 20	4115	871	62
48 25	3419	892	64	52 25	4129	933	62
48 30	3434	955	64	52 30	4144	995	62
48 35	3449	2·0058020	65	52 35	4158	2·0061057	63
48 40	3464	085	64	52 40	4173	120	62
48 45	3479	149	64	52 45	4187	182	63
48 50	3494	213	63	52 50	4202	245	62
48 55	3509	276	64	52 55	4217	307	62
49 0	101·3524	2·0058340	64	53 0	101·4231	2·0061369	62
49 5	3539	404	64	53 5	4246	431	62
49 10	3554	468	64	53 10	4260	493	62
49 15	3569	532	64	53 15	4275	555	62
49 20	3584	596	63	53 20	4289	617	61
49 25	3598	659	64	53 25	4303	678	62
49 30	3613	723	64	53 30	4318	740	62
49 35	3628	787	64	53 35	4332	802	62
49 40	3643	851	63	53 40	4347	864	61
49 45	3658	914	64	53 45	4361	925	62
49 50	3673	978	63	53 50	4375	987	61
49 55	3688	2·0059041	64	53 55	4390	2·0062048	62
50 0	101·3703	2·0059105	63	54 0	101·4404	2·0062110	61
50 5	3717	168	64	54 5	4418	171	61
50 10	3732	232	63	54 10	4433	232	61
50 15	3747	295	64	54 15	4447	293	62
50 20	3762	359	63	54 20	4461	355	61
50 25	3776	422	64	54 25	4476	416	61
50 30	3791	486	63	54 30	4490	447	61
50 35	3806	549	64	54 35	4504	538	61
50 40	3821	613	63	54 40	4518	599	61
50 45	3836	676	63	54 45	4532	660	61
50 50	3851	739	63	54 50	4547	721	60
50 55	3865	802	64	54 55	4561	781	61
51 0	101·3880	2·0059866	63	55 0	101·4575	2·0062842	61
51 5	3895	929	63	55 5	4589	903	61
51 10	3909	992	63	55 10	4603	964	60
51 15	3924	2·0060055	63	55 15	4618	2·0063024	61
51 20	3939	118	63	55 20	4632	085	60
51 25	3954	181	63	55 25	4646	145	60
51 30	3968	243	62	55 30	4660	205	60
51 35	3983	306	63	55 35	4674	265	61
51 40	3998	369	63	55 40	4688	326	60
51 45	4012	432	63	55 45	4702	386	60
51 50	4027	495	62	55 50	4716	446	60
51 55	4041	557	63	55 55	4730	506	60

TABLE XIV.—(*continued*).

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along the Meridian.

Latitude.	Length in feet.	Logarithm.	Diff.	Latitude.	Length in feet.	Logarithm.	Diff.
° ′			+	° ′			+
56 0	101·4744	2·0063566	60	58 0	101·5075	2·0064982	58
56 5	4758	626	60	58 5	5089	2·0065040	58
56 10	4772	686	59	58 10	5102	098	58
56 15	4786	745	60	58 15	5116	156	58
56 20	4800	805	59	58 20	5129	214	57
56 25	4814	864	60	58 25	5143	271	
56 30	4828	924	59	58 30	5156	329	57
56 35	4842	983	60	58 35	5170	386	58
56 40	4856	2·0064043	59	58 40	5183	444	57
56 45	4869	102	59	58 45	5197	501	57
56 50	4883	161	59	58 50	5201	558	57
56 55	4897	220	59	58 55	5223	615	58
57 0	101·4911	2·0064279	59	59 0	101·5237	2·0065673	57
57 5	4925	338	59	59 5	5250	730	57
57 10	4938	397	59	59 10	5263	787	56
57 15	4952	456	59	59 15	5276	843	57
57 20	4966	515	58	59 20	5289	900	56
57 25	4980	573	59	59 25	5303	956	57
57 30	4993	632	58	59 30	5316	2·0066013	56
57 35	5007	690	59	59 35	5329	069	57
57 40	5021	749	58	59 40	5343	126	56
57 45	5034	807	59	59 45	5356	182	57
57 50	5048	866	58	59 50	5369	239	56
57 55	5062	924	58	59 55	5382	295	55
				60 0	101·5395	2·0066351	

TABLE XV.

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along Parallels of Latitude.

Formula: Length in feet $= \dfrac{\pi}{180 \times 3600}\,\nu \cos\lambda$.

Lat.	Length in feet.	Diff.	Logarithm.	Diff.	Lat.	Length in feet.	Diff.	Logarithm.	Diff.
° ′		—		—	° ′		—		—
0 0	101·4538		2·0062683		4 0	101·2083		2·0052163	
0 5	4537	1	2678	5	4 5	1980	103	1720	443
0 10	4533	4	2665	13	4 10	1875	105	1267	453
0 15	4528	5	2642	23	4 15	1767	108	0805	462
0 20	4521	7	2611	31	4 20	1657	110	0334	471
0 25	4511	10	2569	42	4 25	1545	112	2·0049854	480
0 30	4500	11	2519	50	4 30	1432	113	9365	489
0 35	4485	14	2460	59	4 35	1316	116	8867	498
0 40	4470	16	2391	69	4 40	1197	119	8360	507
0 45	4452	18	2314	77	4 45	1077	120	7842	518
0 50	4431	21	2227	87	4 50	0955	122	7317	525
0 55	4409	22	2131	96	4 55	0830	125	6781	536
1 0	101·4385	24	2·0062026	105	5 0	101·0703	127	2·0046237	544
1 5	4358	27	1912	114	5 5	0575	128	5684	554
1 10	4329	29	1789	123	5 10	0444	131	5121	563
1 15	4298	31	1656	133	5 15	0310	134	4549	572
1 20	4265	33	1515	141	5 20	0175	135	3968	581
1 25	4230	35	1364	151	5 25	0038	137	3377	591
1 30	4193	37	1205	159	5 30	100·9899	139	2778	599
1 35	4153	40	1036	169	5 35	9757	142	2170	608
1 40	4112	41	0858	178	5 40	9614	143	1552	618
1 45	4068	44	0671	187	5 45	9468	146	0924	628
1 50	4022	46	0474	197	5 50	9320	148	0288	636
1 55	3974	48	0270	204	5 55	9170	150	2·0039643	645
2 0	101·3924	50	2·0060055	215	6 0	100·9017	153	2·0038987	656
2 5	3872	52	2·0059831	224	6 5	8863	154	8324	663
2 10	3818	54	9598	233	6 10	8707	156	7650	674
2 15	3761	57	9356	242	6 15	8548	159	6968	682
2 20	3703	58	9105	251	6 20	8388	160	6276	692
2 25	3642	61	8845	260	6 25	8225	163	5575	701
2 30	3579	63	8576	269	6 30	8060	165	4865	710
2 35	3514	65	8297	279	6 35	7893	167	4145	720
2 40	3447	67	8010	287	6 40	7724	169	3417	728
2 45	3378	69	7713	297	6 45	7553	171	2679	738
2 50	3306	72	7407	306	6 50	7380	173	1932	747
2 55	3232	74	7091	316	6 55	7204	176	1175	757
3 0	101·3157	75	2·0056767	324	7 0	100·7026	178	2·0030409	766
3 5	3079	78	6434	333	7 5	6847	179	2·0029634	775
3 10	3000	79	6092	342	7 10	6665	182	8849	785
3 15	2917	83	5739	353	7 15	6481	184	8056	793
3 20	2833	84	5379	360	7 20	6295	186	7253	803
3 25	2747	86	5009	370	7 25	6107	188	6442	811
3 30	2659	88	4630	379	7 30	5917	190	5620	822
3 35	2568	91	4242	388	7 35	5724	193	4789	831
3 40	2475	93	3844	398	7 40	5530	194	3949	840
3 45	2380	95	3437	407	7 45	5333	197	3100	849
3 50	2284	96	3022	415	7 50	5134	199	2241	859
3 55	2185	99	2597	425	7 55	4934	200	1374	867
		102		434			203		878

TABLE XV.—(*continued*).

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along Parallels of Latitude.

Lat.	Length in feet.	Diff.	Logarithm.	Diff.	Lat.	Length in feet.	Diff.	Logarithm.	Diff.
° ′		—		—	° ′		—		—
8 0	100·4731	206	2·0020496	887	12 0	99·2513	305	1·9967364	1338
8 5	4525	207	2·0019609	895	12 5	2208	308	66026	1349
8 10	4318	209	8714	906	12 10	1900	311	64677	1358
8 15	4109	211	7808	913	12 15	1589	312	63319	1367
8 20	3898	214	6895	924	12 20	1277	314	61952	1377
8 25	3684	215	5971	933	12 25	0963	316	60575	1387
8 30	3469	218	5038	943	12 30	0647	319	59118	1396
8 35	3251	220	4095	951	12 35	0328	320	57792	1405
8 40	3031	222	3144	962	12 40	0008	323	56387	1415
8 45	2809	224	2182	970	12 45	98·9685	324	54972	1425
8 50	2585	226	1212	980	12 50	9361	327	53547	1435
8 55	2359	229	0232	989	12 55	9034	329	52123	1444
9 0	100·2130	230	2·0009243	999	13 0	98 8705	331	1·9950668	1454
9 5	1900	232	8244	1007	13 5	8374	333	49214	1463
9 10	1668	235	7237	1017	13 10	8041	335	47751	1473
9 15	1433	237	6220	1027	13 15	7706	337	46278	1482
9 20	1196	238	5193	1036	13 20	7369	339	44796	1493
9 25	0958	241	4157	1046	13 25	7030	341	43303	1502
9 30	0717	243	3111	1055	13 30	6689	344	41801	1511
9 35	0474	245	2056	1063	13 35	6345	345	40290	1521
9 40	0229	248	0993	1074	13 40	6000	347	38769	1531
9 45	99·9981	249	1·9999919	1083	13 45	5653	350	37238	1541
9 50	9732	251	8836	1092	13 50	5303	352	35697	1550
9 55	9481	254	7744	1102	13 55	4951	354	34147	1560
10 0	99·9227	255	1·9996642	1111	14 0	98·4597	355	1·9932587	1570
10 5	8972	258	5531	1121	14 5	4242	358	31017	1579
10 10	8714	260	4410	1129	14 10	3884	360	29438	1589
10 15	8454	262	3281	1140	14 15	3524	362	27849	1600
10 20	8192	264	2141	1149	14 20	3162	364	26249	1607
10 25	7928	266	0992	1159	14 25	2798	366	24642	1619
10 30	7662	268	1·9989833	1167	14 30	2432	369	23023	1629
10 35	7394	271	8666	1177	14 35	2063	370	21394	1637
10 40	7123	272	7489	1187	14 40	1693	373	19757	1648
10 45	6851	275	6302	1196	14 45	1320	374	18109	1657
10 50	6576	276	5106	2205	14 50	0946	376	16452	1667
10 55	6300	279	3901	1215	14 55	0570	379	14785	1677
11 0	99·6021	281	1·9982686	1225	15 0	98·0191	381	1·9913108	1687
11 5	5740	283	81461	1234	15 5	97·9810	382	11421	1696
11 10	5457	285	80227	1244	15 10	9428	385	09725	1706
11 15	5172	287	78983	1253	15 15	9043	387	08019	1716
11 20	4885	289	77730	1263	15 20	8656	388	06303	1726
11 25	4596	291	76467	1271	15 25	8268	391	04577	1736
11 30	4305	294	75196	1282	15 30	7877	393	02841	1746
11 35	4011	295	73914	1290	15 35	7484	395	01095	1755
11 40	3716	297	72624	1301	15 40	7089	397	1·9899340	1766
11 45	3419	300	71323	1310	15 45	6692	400	97574	1775
11 50	3119	302	70013	1320	15 50	6292	401	95799	1785
11 55	2817	304	68693	1329	15 55	5891	403	94014	1795

TABLE XV.—(*continued*).

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along Parallels of Latitude.

Lat.		Length in feet.	Diff.	Logarithm.	Diff.	Lat.		Length in feet.	Diff.	Logarithm.	Diff.
°	′		—		—	°	′		—		—
16	0	97·5488	405	1·9892219	1805	20	0	95·3732	502	1·9794265	2290
16	5	5083	408	90414	1814	20	5	3230	505	91975	2301
16	10	4675	409	88600	1825	20	10	2725	507	89674	2311
16	15	4266	412	86775	1834	20	15	2218	509	87363	2321
16	20	3854	413	84941	1845	20	20	1709	511	85042	2332
16	25	3441		83096		20	25	1198		82710	
			416		1854				513		2343
16	30	3025	417	81242	1864	20	30	0685	515	80367	2353
16	35	2608	420	79378	1875	20	35	0170	517	78014	2363
16	40	2188	422	77503	1885	20	40	94·9653	519	75651	2374
16	45	1766	423	75618	1894	20	45	9134	520	73277	2384
16	50	1343	426	73724	1904	20	50	8614	523	70893	2394
16	55	0917		71820		20	55	8091		68499	
			428		1914				525		2406
17	0	97·0489	430	1·9869906	1924	21	0	94·7566	527	1·9766093	2416
17	5	0059	432	67982	1934	21	5	7039	529	63677	2425
17	10	96·9627	434	66048	1945	21	10	6510	531	61252	2437
17	15	9193	436	64103	1954	21	15	5979	533	58815	2447
17	20	8757	438	62149	1964	21	20	5446	535	56368	2458
17	25	8319		60185		21	25	4911		53910	
			440		1974				537		2468
17	30	7879	442	58211	1985	21	30	4374	538	51442	2478
17	35	7437	444	56226	1994	21	35	3836	541	48964	2491
17	40	6993	446	54232	2004	21	40	3295	543	46473	2499
17	45	6547	449	52228	2015	21	45	2752	545	43974	2511
17	50	6098	450	50213	2024	21	50	2207	547	41463	2521
17	55	5648		48189		21	55	1660		38942	
			452		2036				548		2531
18	0	95·5196	455	1·9846153	2044	22	0	94·1112	551	1·9736411	2543
18	5	4741	456	44109	2055	22	5	0561	553	33868	2553
18	10	4285	459	42054	2066	22	10	0008	555	31315	2564
18	15	3826	460	39988	2075	22	15	93·9453	556	28751	2574
18	20	3366	462	37913	2085	22	20	8897	559	26177	2586
18	25	2904		35828		22	25	8338		23591	
			465		2095				561		2596
18	30	2439	466	33733	2106	22	30	7777	563	20995	2606
18	35	1973	469	31627	2116	22	35	7214	564	18389	2618
18	40	1504	471	29511	2126	22	40	6650	567	15771	2627
18	45	1033	472	27385	2136	22	45	6083	569	13144	2639
18	50	0561	475	25249	2147	22	50	5514	570	10505	2650
18	55	0086		23102		22	55	4944		07855	
			476		2156				573		2660
19	0	95·9610	479	1·9820946	2166	23	0	93·4371	574	1·9705195	2672
19	5	9131	481	18780	2178	23	5	3797	577	02523	2681
19	10	8650	483	16602	2188	23	10	3220	578	1·9699842	2694
19	15	8167	484	14414	2197	23	15	2642	581	97148	2703
19	20	7683	487	12217	2208	23	20	2061	582	94445	2715
19	25	7196		10009		23	25	1479		91730	
			489		2218				534		2725
19	30	6707	490	07791	2228	23	30	0895	587	89005	2736
19	35	6217	493	05563	2239	23	35	0308	588	86269	2748
19	40	5724	495	03324	2249	23	40	92·9720	590	83521	2758
19	45	5229	497	01075	2260	23	45	9130	593	80763	2769
19	50	4732	409	1·9798815	2270	23	50	8537	594	77994	2780
19	55	4233	501	96545	2280	23	55	7943	596	75214	2790

TABLE XV.—(*continued*).

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along Parallels of Latitude.

Lat.		Length in feet.	Diff.	Logarithm.	Diff.	Lat.		Length in feet.	Diff.	Logarithm.	Diff.
°	′		—		—	°	′		—		—
24	0	92·7347	598	1·9672424	2802	28	0	89·6454	690	1·9525282	3346
24	5	6749	600	69622	2813	28	5	5764	692	21936	3358
24	10	6149	602	66809	2824	28	10	5072	695	18578	3372
24	15	5547	604	63985	2835	28	15	4377	696	15206	3381
24	20	4943	606	61150	2846	28	20	3681	698	11825	3394
24	25	4337	608	58304	2857	28	25	2983	700	08431	3406
24	30	3729	609	55447	2867	28	30	2283	702	05025	3418
24	35	3120	612	52580	2879	28	35	1581	704	01607	3429
24	40	2508	614	49701	2891	28	40	0877	706	1·9498178	3441
24	45	1894	615	46810	2901	28	45	0171	707	94737	3453
24	50	1279	618	43909	2912	28	50	88·9464	709	91284	3465
24	55	0661	620	40997	2924	28	55	8755	712	87819	3477
25	0	92·0041	621	1·9638073	2934	29	0	88·8043	713	1·9484342	3490
25	5	91·9420	624	35139	2946	29	5	7330	715	80852	3501
25	10	8796	625	32193	2957	29	10	6615	717	77351	3513
25	15	8171	627	29236	2968	29	15	5898	719	73838	3525
25	20	7544	629	29268	2979	29	20	5179	720	70313	3538
25	25	6915	632	23289	2991	29	25	4459	723	66775	3548
25	30	6283	633	20298	3002	29	30	3736	724	63227	3562
25	35	5650	635	17296	3013	29	35	3012	726	59665	3573
25	40	5015	637	14283	3024	29	40	2286	728	56092	3585
25	45	4378	638	11259	3035	29	45	1558	730	52507	3598
25	50	3740	641	08224	3048	29	50	0828	732	48909	3611
25	55	3099	643	05176	3058	29	55	0096	734	45298	3622
26	0	91·2456	645	1·9602118	3070	30	0	87·9362	736	1·9441676	3635
26	5	1811	646	1·9599048	3080	30	5	8626	737	38041	3646
26	10	1165	649	95968	3093	30	10	7889	739	34395	3658
26	15	0516	650	92875	3103	30	15	7150	742	30737	3672
26	20	90·9866	653	89772	3116	30	20	6408	743	27065	3684
26	25	9213	654	86656	3126	30	25	5665	744	23381	3695
26	30	8559	656	83530	3137	30	30	4921	747	19686	3708
26	35	7903	659	80393	3150	30	35	4174	749	15978	3721
26	40	7244	660	77243	3161	30	40	3425	750	12257	3733
26	45	6584	662	74082	3172	30	45	2675	752	08524	3745
26	50	5922	663	70910	3183	30	50	1923	755	04779	3758
26	55	5259	666	67727	3196	30	55	1168	756	01021	3770
27	0	90·4593	668	1·9564531	3207	31	0	87·0412	757	1·9397251	3783
27	5	3925	670	61324	3218	31	5	86·9655	760	93468	3795
27	10	3255	671	58106	3231	31	10	8895	762	89673	3808
27	15	2584	674	54875	3241	31	15	8133	763	85865	3820
27	20	1910	675	51634	3253	31	20	7370	765	82045	3833
27	25	1235	677	48381	3265	31	25	6605	767	78212	3845
27	30	0558	679	45116	3277	31	30	5838	769	74367	3858
27	35	89·9879	681	41839	3288	31	35	5069	770	70509	3871
27	40	9198	683	38551	3299	31	40	4299	773	66638	3882
27	45	8515	685	35252	3312	31	45	3526	774	62756	3897
27	50	7830	687	31940	3323	31	50	2752	776	58859	3909
27	55	7143	689	28617	3335	31	55	1976	778	54950	3921

TABLE XV.—(*continued*).

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along Parallels of Latitude.

Lat.	Length in feet.	Diff.	Logarithm.	Diff.	Lat.	Length in feet.	Diff.	Logarithm.	Diff.
° ′					° ′				
32 0	86·1198	—	1·9351029	—	36 0	82·1742	—	1·9147356	—
32 5	0418	780	47095	3934	36 5	0877	865	42780	4576
32 10	85·9636	782	43148	3947	36 10	0010	867	38190	4590
32 15	8853	783	39188	3960	36 15	81·9141	869	33586	4604
32 20	8068	785	35216	3972	36 20	8270	871	28968	4618
32 25	7281	787	31231	3985	36 25	7398	872	24336	4632
32 30	6492	789	27233	3998	36 30	6524	874	19689	4647
32 35	5701	791	23221	4012	36 35	5648	876	15029	4660
32 40	4909	792	19198	4023	36 40	4770	878	10354	4675
32 45	4114	795	15160	4038	36 45	3891	879	05665	4689
32 50	3318	796	11111	4049	36 50	3011	880	00962	4703
32 55	2520	798	07048	4063	36 55	2128	883	1·9096244	4718
33 0	85·1721	799	1·9302972	4076	37 0	81·1243	885	1·9091512	4732
33 5	0919	802	1·9298883	4089	37 5	0357	886	86766	4746
33 10	0116	803	94781	4102	37 10	80·9469	888	82005	4761
33 15	84·9311	805	90666	4115	37 15	8580	889	77230	4775
33 20	8504	807	86538	4128	37 20	7689	891	72440	4790
33 25	7695	809	82396	4142	37 25	6790	893	67635	4805
33 30	6884	811	78242	4154	37 30	5901	895	62817	4818
33 35	6072	812	74074	4168	37 35	5004	897	57983	4834
33 40	5258	814	69894	4180	37 40	4106	898	53136	4847
33 45	4442	816	65699	4195	37 45	3205	900	48272	4864
33 50	3625	817	61492	4207	37 50	2305	901	43395	4877
33 55	2805	820	57271	4221	37 55	1402	903	38503	4892
34 0	84·1984	821	1·9253037	4234	38 0	80·0497	905	1·9033596	4907
34 5	1161	823	48790	4247	38 5	79·9590	907	28675	4921
34 10	0336	825	44529	4261	38 10	8682	908	23739	4936
34 15	83·9509	827	40255	4274	38 15	7772	910	18788	4951
34 20	8681	828	35968	4287	38 20	6860	912	13822	4966
34 25	7851	830	31667	4301	38 25	5947	913	08840	4982
34 30	7019	832	27352	4315	38 30	5032	915	03844	4996
34 35	6185	834	23024	4328	38 35	4115	917	1·8998833	5011
34 40	5350	835	18683	4341	38 40	3196	919	93807	5026
34 45	4512	838	14327	4356	38 45	2276	920	88766	5641
34 50	3673	839	09959	4368	38 50	1354	922	83710	5056
34 55	2832	841	05577	4382	38 55	0431	923	78638	5072
35 0	83·1990	842	1·9201181	4396	39 0	78·9506	925	1·8973552	5086
35 5	1146	844	1·9196771	4410	39 5	8579	927	68450	5102
35 10	0300	846	92348	4423	39 10	7650	929	63333	5117
35 15	82·9452	848	87911	4437	39 15	6720	930	58201	5132
35 20	8602	850	83461	4450	39 20	5788	932	53054	5147
35 25	7751	851	78996	4465	39 25	4854	934	47891	5163
35 30	6898	853	74517	4479	39 30	3919	935	42713	5178
35 35	6043	855	70026	4491	39 35	2882	937	37520	5193
35 40	5186	857	65519	4507	39 40	2044	938	32311	5209
35 45	4328	858	60999	4520	39 45	1104	940	27086	5225
35 50	3468	860	56466	4533	39 50	0162	942	21846	5240
35 55	2606	862	51918	4548	39 55	77·9218	944	16590	5256
		864		4562			945		5271

TABLE XV.—(*continued*).

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along Parallels of Latitude.

Lat.		Length in feet.	Diff.	Logarithm.	Diff.
°	′		—		—
40	0	77·8273	947	1·8911319	5287
40	5	7326	948	06032	5302
40	10	6378	951	00730	5319
40	15	5427	952	1·8895411	5334
40	20	4475	953	90077	5350
40	25	3522	955	84727	5366
40	30	2567	957	79361	5381
40	35	1610	958	73980	5397
40	40	0652	960	68583	5414
40	45	76·9692	962	63169	5430
40	50	8730	963	57739	5445
40	55	7767	965	52294	5461
41	0	76·6802	966	1·8846833	5478
41	5	5836	968	41355	5493
41	10	4868	970	35862	5511
41	15	3898	972	30351	5526
41	20	2926	973	24825	5543
41	25	1953	975	19282	5559
41	30	0978	976	13723	5575
41	35	0002	978	08148	5592
41	40	75·9024	979	02556	5608
41	45	8045	981	1·8796948	5625
41	50	7064	983	91323	5640
41	55	6081	984	85683	5658
42	0	74·5097	986	1·8780025	5675
42	5	4111	988	74350	5691
42	10	3123	989	68659	5708
42	15	2134	991	62951	5725
42	20	1143	992	57226	5741
42	25	0151	994	51485	5758
42	30	74·9157	996	45727	5775
42	35	8161	997	39952	5792
42	40	7164	999	34160	5809
42	45	6165	1000	28351	5826
42	50	5165	1002	22525	5844
42	55	4163	1003	16681	5859
43	0	74·3160	1005	1·8710822	5878
43	5	2155	1007	04944	5894
43	10	1148	1008	1·8699050	5913
43	15	0140	1010	93137	5928
43	20	73·9130	1011	87209	5947
43	25	8119	1013	81262	59[illegible]4
43	30	7106	1015	75298	5982
43	35	6091	1016	69316	5898
43	40	5075	1018	63318	6017
43	45	4057	1019	57301	6034
43	50	3038	1020	51267	6052
43	55	2018	1023	45215	6070

Lat.		Length in feet.	Diff.	Logarithm.	Diff.
°	′		—		—
44	0	73·0995	1024	1·8639145	6087
44	5	72·9971	1025	33058	6105
44	10	8946	1027	26953	6123
44	15	7919	1029	20830	6141
44	20	6890	1030	14689	6158
44	25	5860	1031	08531	6177
44	30	4829	1033	02354	6195
44	35	3796	1035	1·8596159	6213
44	40	2761	1036	89946	6231
44	45	1725	1038	83715	6250
44	50	0687	1039	77465	6267
44	55	71·9648	1041	71198	6286
45	0	71·8607	1043	1·8564912	6304
45	5	7564	1044	58608	6323
45	10	6520	1045	52285	6341
45	15	5475	1047	45944	6360
45	20	4428	1048	39584	6378
45	25	3380	1050	33206	6397
45	30	2330	1052	26809	6415
45	35	1278	1053	20394	6435
45	40	0225	1055	13959	6453
45	45	70·9170	1056	07506	6472
45	50	8114	1957	01034	6491
45	55	7057	1059	1·8494543	6510
46	0	70·5998	1061	1·8488033	6529
46	5	4937	1062	81504	6548
46	10	3875	1064	74956	6568
46	15	2811	1065	68388	6586
46	20	1746	1066	61802	6605
46	25	0680	1068	55197	6626
46	30	69·9612	1070	48571	6644
46	35	8542	1071	41927	6664
46	40	7471	1072	35263	6683
46	45	6399	1074	28580	6704
46	50	5325	1076	21876	6722
46	55	4249	1077	15154	6743
47	0	69·3172	1078	1·8408411	6761
47	5	2094	1080	01650	6783
47	10	1014	1081	1·8394867	6801
47	15	68·9933	1083	88066	6822
47	20	8850	1085	81214	6842
47	25	7765	1086	74402	6862
47	30	6679	1087	67540	6882
47	35	5592	1089	60658	6902
47	40	4503	1090	53756	6922
47	45	3413	1091	46834	6943
47	50	2322	1093	39891	6962
47	55	1229	1095	32929	6985

TABLE XV.—(*continued*).

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along Parallels of Latitude.

Lat.		Length in feet.	Diff.	Logarithm.	Diff.	Lat.		Length in feet.	Diff.	Logarithm.	Diff.
°	′		—		—	°	′		—		—
48	0	68·0134	1096	1·8325944	7004	52	0	62·5932	1163	1·7965271	8076
48	5	67·9038	1098	18940	7025	52	5	4769	1164	57195	8100
48	10	7940	1099	11915	7046	52	10	3605	1166	49095	8125
48	15	6841	1100	04869	7065	52	15	2439	1167	40970	8149
48	20	5741	1102	1·8297804	7087	52	20	1272	1168	32821	8174
48	25	4639	1103	90717	7108	52	25	0104	1169	24647	8200
48	30	3536	1105	83609	7129	52	30	61·8935	1171	16447	8223
48	35	2431	1106	76480	7149	52	35	7764	1172	08224	8248
48	40	1325	1107	69331	7171	52	40	6592	1174	1·7899976	8273
48	45	0218	1109	62160	7192	52	45	5418	1175	91703	8299
48	50	66·9109	1110	54968	7212	52	50	4243	1176	83404	8324
48	55	7999	1112	47756	7236	52	55	3067	1177	75080	8349
49	0	66·6887	1113	1·8240520	7255	53	0	61·1890	1179	1·7866731	8374
49	5	5774	1115	33265	7277	53	5	0711	1180	58357	8400
49	10	4659	1116	25988	7299	53	10	60·9531	1181	49957	8425
49	15	3543	1118	18689	7320	53	15	8350	1183	41532	8451
49	20	2425	1119	11369	7342	53	20	7167	1184	33081	8478
49	25	1306	1120	04027	7364	53	25	5983	1185	24603	8502
49	30	0186	1122	1·8196663	7385	53	30	4798	1187	16101	8529
49	35	65·9064	1123	89278	7407	53	35	3611	1188	07572	8555
49	40	7941	1124	81871	7429	53	40	2423	1189	1·7799017	8581
49	45	6817	1126	74442	7452	53	45	1234	1190	90436	8607
49	50	5691	1127	66990	7472	53	50	0044	1192	81829	8634
49	55	4564	1129	59518	7496	53	55	59·8852	1193	73195	8660
50	0	65·3435	1130	1·8152022	7518	54	0	59·7659	1194	1·7764535	8687
50	5	2305	1132	44504	7540	54	5	6465	1196	55848	8713
50	10	1173	1133	36964	7563	54	10	5269	1197	47135	8741
50	15	0040	1134	29401	7585	54	15	4072	1198	38394	8767
50	20	64·8906	1136	21816	7607	54	20	2874	1199	29627	8795
50	25	7770	1137	14209	7631	54	25	1675	1201	20832	8822
50	30	6633	1138	06578	7652	54	30	0474	1202	12010	8849
50	35	5495	1140	1·8098926	7675	54	35	58·9272	1203	03161	8875
50	40	4355	1141	91251	7699	54	40	8069	1204	1·7694286	8904
50	45	3214	1143	83552	7722	54	45	6865	1206	85382	8931
50	50	2071	1144	75830	7744	54	50	5659	1207	76451	8959
50	55	0927	1145	68086	7768	54	55	4452	1208	67492	8987
51	0	63·9782	1147	1·8060318	7791	55	0	58·3244	1209	1·7658505	9015
51	5	8635	1148	52527	7814	55	5	2035	1211	49490	9042
51	10	7487	1149	44713	7838	55	10	0824	1212	40448	9071
51	15	6338	1151	36875	7861	55	15	57·9612	1213	31337	9100
51	20	5187	1152	29014	7884	55	20	8399	1214	22277	9127
51	25	4035	1154	21130	7908	55	25	7185	1216	13150	9157
51	30	2881	1155	13222	7932	55	30	5969	1217	03993	9185
51	35	1726	1156	05290	7956	55	35	4752	1218	1·7594808	9213
51	40	0570	1157	1·7997334	7979	55	40	3534	1219	85595	9243
51	45	62·9413	1159	89355	8004	55	45	2315	1220	76352	9272
51	50	8254	1160	81351	8027	55	50	1095	1222	67080	9300
51	55	7094	1162	73324	8053	55	55	56·9873	1223	57780	9330

TABLE XV.—(*continued*).

Linear Value in Feet of One Second of Arc and its Logarithm, Measured along Parallels of Latitude.

Lat.	Length in feet.	Diff.	Logarithm.	Diff.	Lat.	Length in feet.	Diff.	Logarithm.	Diff.
° ′		—		—	° ′		—		—
56 0	56·8650	1224	1·7548450	9360	58 0	53·8940	1253	1·7315402	10105
56 5	7426	1226	39090	9389	58 5	7687	1254	05297	10139
56 10	6200	1226	29701	9418	58 10	6433	1255	1·7295158	10172
56 15	4974	1228	20283	9449	58 15	5178	1256	84986	10205
56 20	3746	1229	10834	9478	58 20	3922	1257	74781	10237
56 25	2517	1230	01356	9508	58 25	2665	1258	64544	10272
56 30	1287	1231	1·7491848	9538	58 30	1407	1259	54272	10305
56 35	0056	1233	82310	9570	58 35	0148	1261	43967	10340
56 40	55·8823	1234	72740	9599	58 40	52·8887	1262	33627	10373
56 45	7589	1235	63141	9630	58 45	7625	1263	23254	10408
56 50	6354	1236	53511	9661	58 50	6362	1264	12846	10440
56 55	5118	1238	43850	9691	58 55	5098	1265	02406	10477
57 0	55·3880	1238	1·7434159	9723	59 0	52·3833	1266	1·7191929	10511
57 5	2642	1240	24436	9754	59 5	2567	1267	81418	10545
57 10	1402	1241	14682	9784	59 10	1300	1269	70873	10581
57 15	0161	1242	04898	9816	59 15	0031	1270	60292	10617
57 20	54·8919	1243	1·7395082	9848	59 20	51·8761	1271	49675	10651
57 25	7676	1245	85234	9880	59 25	7490	1271	39024	10686
57 30	6431	1246	75354	9912	59 30	6219	1273	1·7128338	10723
57 35	5185	1246	65442	9943	59 35	4946	1274	17615	10758
57 40	3939	1248	55499	9976	59 40	3672	1275	06857	10794
57 45	2691	1249	45523	10007	59 45	2397	1277	1·7096063	10831
57 50	1442	1251	35516	10041	59 50	1120	1277	85232	10867
57 55	0191	1251	25475	10073	59 55	50·9843	1278	74365	10903
					60 0	50·8565		1·7063462	

TABLE XVI.

ACCELERATION

H	M	S	M	S	S	Dec.
1	0	9·86	1	0·16	1	·00
2	0	19·71	2	0·33	2	·00
3	0	29·57	3	0·49	3	·01
4	0	39·43	4	0·66	4	·01
5	0	49·28	5	0·82	5	·01
6	0	59·14	6	0·98	6	·02
7	1	9·00	7	1·15	7	·02
8	1	18·85	8	1·31	8	·02
9	1	28·71	9	1·48	9	·02
10	1	38·56	10	1·64	10	·03
11	1	48·42	11	1·81	11	·03
12	1	58·28	12	1·97	12	·03
13	2	8·13	13	2·13	13	·04
14	2	17·99	14	2·30	14	·04
15	2	27·85	15	2·46	15	·04
16	2	37·70	16	2·63	16	·04
17	2	47·56	17	2·79	17	·05
18	2	57·42	18	2·96	18	·05
19	3	7·27	19	3·12	19	·05
20	3	17·13	20	3·29	20	·05
21	3	26·99	21	3·45	21	·06
22	3	36·84	22	3·61	22	·06
23	3	46·70	23	3·78	23	·06
24	3	56·56	24	3·94	24	·07
			25	4·11	25	·07
			26	4·27	26	·07
			27	4·44	27	·07
			28	4·60	28	·08
			29	4·76	29	·08
			30	4·93	30	·08
			31	5·09	31	·08
			32	5·26	32	·09
			33	5·42	33	·09
			34	5·59	34	·09
			35	5·75	35	·10
			36	5·91	36	·10
			37	6·08	37	·10
			38	6·24	38	·11
			39	6·40	39	·11
			40	6·57	40	·11
			41	6·74	41	·11
			42	6·90	42	·12
			43	7·06	43	·12
			44	7·23	44	·12
			45	7·39	45	·12
			46	7·56	46	·13
			47	7·72	47	·13
			48	7·89	48	·13
			49	8·05	49	·14
			50	8·21	50	·14
			51	8·38	51	·14
			52	8·54	52	·14
			53	8·71	53	·15
			54	8·87	54	·15
			55	9·04	55	·15
			56	9·20	56	·15
			57	9·36	57	·16
			58	9·53	58	·16
			59	9·69	59	·16
			60	9·86	60	·16

TABLE XVII.

RETARDATION

H	M	S	M	S	S	Dec.
1	0	9·83	1	0·16	1	·00
2	0	19·66	2	0·33	2	·00
3	0	29·49	3	0·49	3	·01
4	0	39·32	4	0·66	4	·01
5	0	49·15	5	0·82	5	·01
6	0	58·98	6	0·98	6	·02
7	1	8·81	7	1·15	7	·02
8	1	18·64	8	1·31	8	·02
9	1	28·47	9	1·47	9	·02
10	1	38·30	10	1·64	10	·03
11	1	48·13	11	1·80	11	·03
12	1	57·95	12	1·97	12	·03
13	2	7·78	13	2·13	13	·04
14	2	17·61	14	2·29	14	·04
15	2	27·44	15	2·46	15	·04
16	2	37·27	16	2·62	16	·04
17	2	47·10	17	2·78	17	·05
18	2	56·93	18	2·95	18	·05
19	3	6·76	19	3·11	19	·05
20	3	16·59	20	3·28	20	·05
21	3	26·42	21	3·44	21	·06
22	3	36·25	22	3·60	22	·06
23	3	46·08	23	3·77	23	·06
24	3	55·91	24	3·93	24	·07
			25	4·10	25	·07
			26	4·26	26	·07
			27	4·42	27	·07
			28	4·59	28	·08
			29	4·75	29	·08
			30	4·91	30	·08
			31	5·08	31	·08
			32	5·24	32	·09
			33	5·41	33	·09
			34	5·57	34	·09
			35	5·73	35	·10
			36	5·90	36	·10
			37	6·06	37	·10
			38	6·23	38	·11
			39	6·39	39	·11
			40	6·55	40	·11
			41	6·72	41	·11
			42	6·88	42	·12
			43	7·04	43	·12
			44	7·21	44	·12
			45	7·37	45	·12
			46	7·54	46	·13
			47	7·70	47	·13
			48	7·86	48	·13
			49	8·03	49	·14
			50	8·19	50	·14
			51	8·36	51	·14
			52	8·52	52	·14
			53	8·68	53	·15
			54	8·85	54	·15
			55	9·01	55	·15
			56	9·17	56	·15
			57	9·34	57	·16
			58	9·50	58	·16
			59	9·67	59	·16
			60	9·83	60	·16

TABLE XVIII.

CORRECTION OF THE MOON'S EQUATORIAL PARALLAX FOR THE FIGURE OF THE EARTH

Lat.	Horizontal Parallax 54′	56′	58′	60′	62′
0°	″0	″0	″0	″0	″0
8	0·2	0·2	0·2	0·2	0·2
16	0·8	0·8	0·8	0·9	0·9
20	1·2	1·3	1·3	1·4	1·4
24	1·8	1·8	1·9	2·0	2·0
28	2·4	2·5	2·5	2·6	2·7
32	3·0	3·1	3·2	3·3	3·4
36	3·7	3·9	4·0	4·1	4·2
40	4·4	4·6	4·8	4·9	5·1
44	5·2	5·4	5·6	5·8	6·0
48	5·9	6·1	6·4	6·6	6·8
52	6·7	6·9	7·2	7·4	7·7
56	7·4	7·7	7·9	8·2	8·5
60	8·1	8·4	8·7	9·0	9·3
64	8·7	9·0	9·4	9·7	10·0
68	9·3	9·6	10·0	10·3	10·6
72	9·8	10·1	10·5	10·9	11·2
76	10·2	10·6	10·9	11·3	11·7
80	10·5	10·9	11·2	11·6	12·0

TABLE XIX.

AUGMENTATION OF THE MOON'S SEMIDIAMETER

App. Alt.	Semidiameter 14′ 30″	15′ 0″	15′ 30″	16′ 0″	16′ 30″	17′ 0″
0°	0′1	0′1	0′1	0′1	0′1	0′1
2	0·6	0·6	0·7	0·7	0·8	0·8
4	1·0	1·1	1·2	1·3	1·4	1·5
6	1·5	1·6	1·7	1·9	2·0	2·1
8	2·0	2·1	2·2	2·4	2·5	2·7
10	2·4	2·7	2·8	3·0	3·2	3·3
12	2·9	3·2	3·3	3·5	3·7	4·0
14	3·4	3·6	3·8	4·1	4·4	4·6
16	3·9	4·1	4·4	4·7	5·0	5·2
18	4·3	4·6	4·9	5·2	5·5	5·9
21	4·9	5·3	5·7	6·0	6·4	6·7
24	5·6	6·0	6·4	6·8	7·2	7·7
27	6·2	6·7	7·2	7·6	8·1	8·6
30	6·9	7·4	7·9	8·4	8·9	9·4
33	7·5	8·0	8·6	9·1	9·6	10·3
36	8·0	8·6	9·2	9·8	10·4	11·1
39	8·6	9·2	9·9	10·5	11·1	11·8
42	9·1	9·8	10·4	11·2	11·8	12·6
45	9·7	10·3	11·0	11·8	12·5	13·3
48	10·2	10·9	11·6	12·4	13·1	14·0
51	10·6	11·3	12·1	12·9	13·7	14·6
54	11·1	11·8	12·6	13·5	14·3	15·2
57	11·5	12·3	13·1	14·0	14·8	15·7
63	12·2	13·0	13·9	14·8	15·7	16·7
70	12·7	13·7	14·7	15·7	16·6	17·6
78	13·3	14·3	15·3	16·3	17·3	18·4
90	13·5	14·6	15·6	16·7	17·6	18·6

TABLE XX.

Reduction of Latitude $\phi - \phi'$.

ϕ = Geographical Latitude. ϕ' = Geocentric Latitude.

Compression = $\frac{1}{293·4663}$.

ϕ		$\phi-\phi'$		Diff.	ϕ		$\phi-\phi'$		Diff.	ϕ		$\phi-\phi'$		Diff.
°	′	′	″	+	°	′	′	″	+	°	′	′	″	+
0	0	0	0	24·487	32	0	10	31·853	1·793	39	0	11	28·180	·853
1	0	0	24·487	24·458	32	10	10	33·646	1·772	39	10	11	29·033	·829
2	0	0	48·945	24·399	32	20	10	35·418	1·751	39	20	11	29·862	·806
3	0	1	13·344	24·311	32	30	10	37·169	1·729	39	30	11	30·668	·783
4	0	1	37·655	24·192	32	40	10	38·898	1·708	39	40	11	31·451	·760
5	0	2	1·847	24·045	32	50	10	40·606	1·686	39	50	11	32·211	·736
6	0	2	25·892	23·870	33	0	10	42·292	1·664	40	0	11	32·947	·713
7	0	2	49·762	23·665	33	10	10	43·956	1·643	40	10	11	33·660	·689
8	0	3	13·427	23·432	33	20	10	45·599	1·621	40	20	11	34·349	·666
9	0	3	36·859	23·170	33	30	10	47·220	1·600	40	30	11	35·015	·642
10	0	4	0·029	22·879	33	40	10	48·820	1·578	40	40	11	35·657	·619
11	0	4	22·908	22·564	33	50	10	50·398	1·555	40	50	11	36·276	·595
12	0	4	45·472	22·218	34	0	10	51·953	1·533	41	0	11	36·871	·572
13	0	5	7·690	21·847	34	10	10	53·486	1·512	41	10	11	37·443	·548
14	0	5	29·537	21·449	34	20	10	54·998	1·490	41	20	11	37·991	·524
15	0	5	50·986	21·026	34	30	10	56·488	1·467	41	30	11	38·515	·501
16	0	6	12·012	20·576	34	40	10	57·955	1·445	41	40	11	39·016	·477
17	0	6	32·588	20·102	34	50	10	59·400	1·423	41	50	11	39·493	·454
18	0	6	52·690	19·603	35	0	11	0·823	1·400	42	0	11	39·947	·430
19	0	7	12·293	19·081	35	10	11	2·223	1·378	42	10	11	40·377	·406
20	0	7	31·374	18·535	35	20	11	3·601	1·356	42	20	11	40·783	·382
21	0	7	49·909	17·968	35	30	11	4·957	1·333	42	30	11	41·165	·359
22	0	8	7·877	17·377	35	40	11	6·290	1·311	42	40	11	41·524	·335
23	0	8	25·254	16·765	35	50	11	7·601	1·288	42	50	11	41·859	·312
24	0	8	42·019	16·135	36	0	11	8·889	1·266	43	0	11	42·171	·288
25	0	8	58·154	15·482	36	10	11	10·155	1·243	43	10	11	42·459	·264
26	0	9	13·636	14·813	36	20	11	11·398	1·220	43	20	11	42·723	·240
27	0	9	28·449	14·124	36	30	11	12·618	1·198	43	30	11	42·963	·216
28	0	9	42·573	13·419	36	40	11	13·816	1·175	43	40	11	43·179	·193
29	0	9	55·992	12·696	36	50	11	14·991	1·152	43	50	11	43·372	·169
30	0	10	8·688	2·045	37	0	11	16·143	1·129	44	0	11	43·541	·145
30	10	10	10·733	2·024	37	10	11	17·272	1·107	44	10	11	43·686	·121
30	20	10	12·757	2·004	37	20	11	18·379	1·084	44	20	11	43·807	·097
30	30	10	14·761	1·983	37	30	11	19·463	1·060	44	30	11	43·904	·074
30	40	10	16·744	1·962	37	40	11	20·523	1·038	44	40	11	43·978	·050
30	50	10	18·706	1·941	37	50	11	21·561	1·015	44	50	11	44·028	·026
31	0	10	20·647	1·920	38	0	11	22·576	·992	45	0	11	44·054	·002
31	10	10	22·567	1·900	38	10	11	23·568	·968	45	10	11	44·056	−·022
31	20	10	24·467	1·878	38	20	11	24·536	·946	45	20	11	44·034	−·046
31	30	10	26·345	1·857	38	30	11	25·482	·923	45	30	11	43·988	−·069
31	40	10	28·202	1·836	38	40	11	26·405	·899	45	40	11	43·919	−·093
31	50	10	30·038	1·815	38	50	11	27·304	·876	45	50	11	43·826	−·117

TABLE XX.—(*continued*).

Reduction of Latitude $\phi-\phi'$.

φ °	φ ′	φ−φ′ ′	φ−φ′ ″	Diff.	φ °	φ ′	φ−φ′ ′	φ−φ′ ″	Diff.	φ °	φ ′	φ−φ′ ′	φ−φ′ ″	Diff.
46	0	11	43·709	·141	52	30	11	20·665	1·060	59	0	10	22·638	1·925
46	10	11	43·568	·165	52	40	11	19·605	1·082	59	10	10	20·713	1·947
46	20	11	43·403	·189	52	50	11	18·523	1·106	59	20	10	18·766	1·968
46	30	11	43·214	·212	53	0	11	17·417	1·129	59	30	10	16·798	1·988
46	40	11	43·002	·236	53	10	11	16·288	1·151	59	40	10	14·810	2·010
46	50	11	42·766	·260	53	20	11	15·137	1·175	59	50	10	12·800	2·030
47	0	11	42·506	·284	53	30	11	13·962	1·198	60	0	10	10·770	12·618
47	10	11	42·222	·307	53	40	11	12·764	1·220	61	0	9	58·152	13·351
47	20	11	41·915	·331	53	50	11	11·544	1·243	62	0	9	44·801	14·066
47	30	11	41·584	·355	54	0	11	10·301	1·266	63	0	9	30·735	14·767
47	40	11	41·229	·379	54	10	11	9·015	1·288	64	0	9	15·968	15·448
47	50	11	40·850	·403	54	20	11	7·747	1·312	65	0	9	0·520	16·111
48	0	11	40·447	·426	54	30	11	6·435	1·334	66	0	8	44·409	16·755
48	10	11	40·021	·450	54	40	11	5·101	1·356	67	0	8	27·654	17·377
48	20	11	39·571	·474	54	50	11	3·745	1·379	68	0	8	10·277	17·978
48	30	11	39·097	·497	55	0	11	2·366	1·401	69	0	7	52·299	18·559
48	40	11	38·600	·521	55	10	11	0·965	1·424	70	0	7	33·740	19·115
48	50	11	38·079	·545	55	20	10	59·541	1·446	71	0	7	14·625	19·649
49	0	11	37·534	·568	55	30	10	58·095	1·469	72	0	6	54·976	20·160
49	10	11	36·966	·592	55	40	10	56·626	1·491	73	0	6	34·816	20·644
49	20	11	36·374	·616	55	50	10	55·135	1·513	74	0	6	14·172	21·104
49	30	11	35·758	·640	56	0	10	53·622	1·535	75	0	5	53·068	21·539
49	40	11	35·118	·663	56	10	10	52·087	1·557	76	0	5	31·529	21·945
49	50	11	34·455	·686	56	20	10	50·530	1·580	77	0	5	9·584	22·326
50	0	11	33·769	·710	56	30	10	48·950	1·602	78	0	4	47·258	22·681
50	10	11	33·059	·733	56	40	10	47·348	1·623	79	0	4	24·577	23·004
50	20	11	32·326	·757	56	50	10	45·725	1·646	80	0	4	1·573	23·302
50	30	11	31·569	·780	57	0	10	44·079	1·668	81	0	3	38·271	23·570
50	40	11	30·789	·804	57	10	10	42·411	1·689	82	0	3	14·701	23·811
50	50	11	29·985	·827	57	20	10	40·722	1·712	83	0	2	50·890	24·020
51	0	11	29·158	·850	57	30	10	39·010	1·733	84	0	2	26·870	24·201
51	10	11	28·308	·874	57	40	10	37·277	1·755	85	0	2	2·669	24·352
51	20	11	27·434	·897	57	50	10	35·522	1·776	86	0	1	38·317	24·473
51	30	11	26·537	·921	58	0	10	33·746	1·798	87	0	1	13·844	24·565
51	40	11	25·616	·944	58	10	10	31·948	1·819	88	0	0	49·279	24·624
51	50	11	24·672	·967	58	20	10	30·129	1·841	89	0	0	24·655	24·655
52	0	11	23·705	·990	58	30	10	28·288	1·862	90	0	0	0	
52	10	11	22·715	1·013	58	40	10	26·426	1·883					
52	20	11	21·702	1·037	58	50	10	24·543	1·905					

TABLE XXI.

Semi-diurnal and Semi-nocturnal Arches, showing the time of the Rising and Setting of the Sun, Moon, or Equatorial Stars.

Declination.

Lat.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	Lat.
°	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	°
1	6 0	6 0	6 0	6 0	6 0	6 0	6 0	6 0	6 1	6 1	6 1	6 1	6 1	6 1	1
2	6 0	6 0	6 0	6 0	6 1	6 1	6 1	6 1	6 1	6 1	6 1	6 2	6 2	6 2	2
3	6 0	6 0	6 0	6 1	6 1	6 1	6 1	6 1	6 2	6 2	6 2	6 2	6 3	6 3	3
4	6 0	6 0	6 1	6 1	6 1	6 1	6 2	6 2	6 2	6 3	6 3	6 3	6 3	6 4	4
5	6 0	6 0	6 1	6 1	6 1	6 2	6 2	6 2	6 3	6 3	6 4	6 4	6 4	6 5	5
6	6 0	6 0	6 1	6 1	6 2	6 2	6 3	6 3	6 3	6 4	6 4	6 5	6 5	6 6	6
7	6 0	6 0	6 1	6 1	6 2	6 2	6 3	6 3	6 4	6 4	6 5	6 5	6 6	6 6	7
8	6 0	6 1	6 1	6 2	6 2	6 3	6 3	6 4	6 5	6 5	6 6	6 6	6 7	6 7	8
9	6 0	6 1	6 1	6 2	6 3	6 3	6 4	6 4	6 5	6 6	6 6	6 7	6 8	6 8	9
10	6 0	6 1	6 1	6 2	6 3	6 4	6 4	6 5	6 6	6 6	6 7	6 8	6 9	6 9	10
11	6 0	6 1	6 2	6 2	6 3	6 4	6 5	6 5	6 6	6 7	6 8	6 9	6 9	6 10	11
12	6 0	6 1	6 2	6 3	6 3	6 4	6 5	6 6	6 7	6 8	6 9	6 9	6 10	6 11	12
13	6 0	6 1	6 2	6 3	6 4	6 5	6 6	6 6	6 7	6 8	6 9	6 10	6 11	6 12	13
14	6 0	6 1	6 2	6 3	6 4	6 5	6 6	6 7	6 8	6 9	6 10	6 11	6 12	6 13	14
15	6 0	6 1	6 2	6 3	6 4	6 5	6 6	6 8	6 9	6 10	6 11	6 12	6 13	6 14	15
16	6 0	6 1	6 2	6 3	6 5	6 6	6 7	6 8	6 9	6 10	6 12	6 13	6 14	6 15	16
17	6 0	6 1	6 2	6 4	6 5	6 6	6 7	6 9	6 10	6 11	6 12	6 14	6 15	6 16	17
18	6 0	6 1	6 3	6 4	6 5	6 7	6 8	6 9	6 10	6 12	6 13	6 14	6 16	6 17	18
19	6 0	6 1	6 3	6 4	6 6	6 7	6 8	6 10	6 11	6 13	6 14	6 15	6 17	6 18	19
20	6 0	6 1	6 3	6 4	6 6	6 7	6 9	6 10	6 12	6 13	6 15	6 16	6 18	6 19	20
21	6 0	6 2	6 3	6 5	6 6	6 8	6 9	6 11	6 12	6 14	6 16	6 17	6 19	6 20	21
22	6 0	6 2	6 3	6 5	6 6	6 8	6 10	6 11	6 13	6 15	6 16	6 18	6 20	6 21	22
23	6 0	6 2	6 3	6 5	6 7	6 9	6 10	6 12	6 14	6 15	6 17	6 19	6 21	6 22	23
24	6 0	6 2	6 4	6 5	6 7	6 9	6 11	6 13	6 14	6 16	6 18	6 20	6 22	6 24	24
25	6 0	6 2	6 4	6 6	6 7	6 9	6 11	6 13	6 15	6 17	6 19	6 21	6 23	6 25	25
26	6 0	6 2	6 4	6 6	6 8	6 10	6 12	6 14	6 16	6 18	6 20	6 22	6 24	6 26	26
27	6 0	6 2	6 4	6 6	6 8	6 10	6 12	6 14	6 16	6 19	6 21	6 23	6 25	6 27	27
28	6 0	6 2	6 4	6 6	6 9	6 11	6 13	6 15	6 17	6 19	6 22	6 24	6 26	6 28	28
29	6 0	6 2	6 4	6 7	6 9	6 11	6 13	6 16	6 18	6 20	6 22	6 25	6 27	6 29	29
30	6 0	6 2	6 5	6 7	6 9	6 12	6 14	6 16	6 19	6 21	6 23	6 26	6 28	6 31	30
31	6 0	6 2	6 5	6 7	6 10	6 12	6 14	6 17	6 19	6 22	6 24	6 27	6 29	6 32	31
32	6 0	6 2	6 5	6 8	6 10	6 13	6 15	6 18	6 20	6 23	6 25	6 28	6 31	6 33	32
33	6 0	6 3	6 5	6 8	6 10	6 13	6 16	6 18	6 21	6 24	6 26	6 29	6 32	6 34	33
34	6 0	6 3	6 5	6 8	6 11	6 14	6 16	6 19	6 22	6 25	6 27	6 30	6 33	6 36	34
35	6 0	6 3	6 6	6 8	6 11	6 14	6 17	6 20	6 23	6 25	6 28	6 31	6 34	6 37	35
36	6 0	6 3	6 6	6 9	6 12	6 15	6 18	6 20	6 23	6 26	6 29	6 32	6 36	6 39	36
37	6 0	6 3	6 6	6 9	6 12	6 15	6 18	6 21	6 24	6 27	6 31	6 34	6 37	6 40	37
38	6 0	6 3	6 6	6 9	6 13	6 16	6 19	6 22	6 25	6 28	6 32	6 35	6 38	6 42	38
39	6 0	6 3	6 6	6 10	6 13	6 16	6 20	6 23	6 26	6 29	6 33	6 36	6 40	6 43	39
40	6 0	6 3	6 7	6 10	6 13	6 17	6 20	6 24	6 27	6 31	6 34	6 38	6 41	6 45	40
41	6 0	6 3	6 7	6 10	6 14	6 17	6 21	6 25	6 28	6 32	6 35	6 39	6 43	6 46	41
42	6 0	6 4	6 7	6 11	6 14	6 18	6 22	6 25	6 29	6 33	6 37	6 40	6 44	6 48	42
43	6 0	6 4	6 7	6 11	6 15	6 19	6 22	6 26	6 30	6 34	6 38	6 42	6 46	6 50	43
44	6 0	6 4	6 8	6 12	6 15	6 19	6 23	6 27	6 31	6 35	6 39	6 43	6 47	6 52	44
45	6 0	6 4	6 8	6 12	6 16	6 20	6 24	6 28	6 32	6 36	6 41	6 45	6 49	6 53	45
46	6 0	6 4	6 8	6 12	6 17	6 21	6 25	6 29	6 33	6 38	6 42	6 46	6 51	6 55	46
47	6 0	6 4	6 9	6 13	6 17	6 22	6 26	6 30	6 35	6 39	6 44	6 48	6 53	6 57	47
48	6 0	6 4	6 9	6 13	6 18	6 22	6 27	6 31	6 36	6 41	6 45	6 50	6 55	6 59	48
49	6 0	6 5	6 9	6 14	6 18	6 23	6 28	6 32	6 37	6 42	6 47	6 52	6 57	7 2	49
50	6 0	6 5	6 10	6 14	6 19	6 24	6 29	6 34	6 39	6 44	6 49	6 54	6 59	7 4	50
51	6 0	6 5	6 10	6 15	6 20	6 25	6 30	6 35	6 40	6 45	6 50	6 56	7 1	7 6	51
52	6 0	6 5	6 10	6 15	6 21	6 26	6 31	6 36	6 41	6 47	6 52	6 58	7 3	7 9	52
53	6 0	6 5	6 11	6 16	6 21	6 27	6 32	6 38	6 43	6 49	6 54	7 0	7 6	7 11	53
54	6 0	6 5	6 11	6 17	6 22	6 28	6 33	6 39	6 45	6 50	6 56	7 2	7 8	7 14	54
55	6 0	6 6	6 11	6 17	6 23	6 29	6 35	6 40	6 46	6 52	6 59	7 4	7 11	7 17	55
56	6 0	6 6	6 12	6 18	6 24	6 30	6 36	6 42	6 48	6 54	7 1	7 7	7 13	7 20	56
57	6 0	6 6	6 12	6 19	6 25	6 31	6 37	6 44	6 50	6 56	7 3	7 10	7 16	7 23	57
58	6 0	6 6	6 13	6 19	6 26	6 32	6 39	6 45	6 52	6 59	7 6	7 12	7 20	7 27	58
59	6 0	6 7	6 13	6 20	6 27	6 33	6 40	6 47	6 54	7 1	7 8	7 15	7 23	7 30	59
60	6 0	6 7	6 14	6 21	6 28	6 35	6 42	6 49	6 56	7 4	7 11	7 19	7 26	7 34	60

TABLE XXI.—(*continued*).

Semi-diurnal and Semi-nocturnal Arches, showing the time of the Rising and Setting of the Sun, Moon, or Equatorial Stars.

Declination.

Lat.	14°	15°	16°	17°	18°	19°	20°	21°	21½°	22°	22½°	23°	23° 23′	Lat.
°	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	°
1	6 1	6 1	6 1	6 1	6 1	6 1	6 1	6 2	6 2	6 2	6 2	6 2	6 2	1
2	6 2	6 2	6 2	6 2	6 3	6 3	6 3	6 3	6 3	6 3	6 3	6 3	6 3	2
3	6 3	6 3	6 3	6 4	6 4	6 4	6 4	6 5	6 5	6 5	6 5	6 5	6 5	3
4	6 4	6 4	6 5	6 5	6 5	6 6	6 6	6 6	6 6	6 6	6 7	6 7	6 7	4
5	6 5	6 5	6 6	6 6	6 7	6 7	6 7	6 8	6 8	6 8	6 8	6 9	6 9	5
6	6 6	6 6	6 7	6 7	6 8	6 8	6 9	6 9	6 10	6 10	6 10	6 10	6 10	6
7	6 7	6 8	6 8	6 9	6 9	6 10	6 10	6 11	6 11	6 11	6 12	6 12	6 12	7
8	6 8	6 9	6 8	6 10	6 10	6 11	6 12	6 12	6 13	6 13	6 13	6 14	6 14	8
9	6 9	6 10	6 10	6 11	6 12	6 13	6 13	6 14	6 14	6 15	6 15	6 15	6 16	9
10	6 10	6 11	6 12	6 12	6 13	6 14	6 15	6 16	6 16	6 16	6 17	6 17	6 18	10
11	6 11	6 12	6 13	6 14	6 14	6 15	6 16	6 17	6 18	6 18	6 18	6 19	6 19	11
12	6 12	6 13	6 14	6 15	6 16	6 17	6 18	6 19	6 19	6 20	6 20	6 21	6 21	12
13	6 13	6 14	6 15	6 16	6 17	6 18	6 19	6 20	6 21	6 21	6 22	6 22	6 23	13
14	6 14	6 15	6 16	6 17	6 19	6 20	6 21	6 22	6 23	6 23	6 24	6 24	6 25	14
15	6 15	6 16	6 18	6 19	6 20	6 21	6 22	6 24	6 24	6 25	6 25	6 26	6 27	15
16	6 16	6 18	6 19	6 20	6 21	6 23	6 24	6 25	6 26	6 27	6 27	6 28	6 29	16
17	6 17	6 19	6 20	6 21	6 23	6 24	6 26	6 27	6 28	6 28	6 29	6 30	6 31	17
18	6 19	6 20	6 21	6 23	6 24	6 26	6 27	6 29	6 29	6 30	6 31	6 32	6 32	18
19	6 20	6 21	6 23	6 24	6 26	6 27	6 29	6 30	6 31	6 32	6 33	6 34	6 34	19
20	6 21	6 22	6 24	6 26	6 27	6 29	6 30	6 32	6 33	6 34	6 35	6 36	6 36	20
21	6 22	6 24	6 25	6 27	6 29	6 30	6 32	6 34	6 35	6 36	6 37	6 38	6 38	21
22	6 23	6 25	6 27	6 28	6 30	6 32	6 34	6 36	6 37	6 38	6 39	6 40	6 41	22
23	6 24	6 26	6 28	6 30	6 32	6 34	6 36	6 38	6 38	6 39	6 40	6 42	6 43	23
24	6 25	6 27	6 29	6 31	6 33	6 35	6 37	6 39	6 40	6 41	6 42	6 44	6 45	24
25	6 27	6 29	6 31	6 33	6 35	6 37	6 39	6 41	6 42	6 43	6 45	6 46	6 47	25
26	6 28	6 30	6 32	6 34	6 36	6 39	6 41	6 43	6 44	6 45	6 47	6 48	6 49	26
27	6 29	6 31	6 34	6 36	6 38	6 40	6 43	6 45	6 46	6 48	6 49	6 50	6 51	27
28	6 30	6 33	6 35	6 37	6 40	6 42	6 45	6 47	6 48	6 50	6 51	6 52	6 53	28
29	6 32	6 34	6 37	6 39	6 42	6 44	6 47	6 49	6 50	6 52	6 53	6 54	6 56	29
30	6 33	6 36	6 38	6 41	6 43	6 46	6 49	6 51	6 53	6 54	6 55	6 57	6 58	30
31	6 34	6 37	6 40	6 42	6 45	6 48	6 51	6 53	6 55	6 56	6 58	6 59	7 0	31
32	6 36	6 39	6 41	6 44	6 47	6 50	6 53	6 56	6 57	6 58	7 0	7 2	7 3	32
33	6 37	6 40	6 43	6 46	6 49	6 53	6 55	6 58	6 59	7 1	7 2	7 4	7 5	33
34	6 39	6 42	6 45	6 48	6 51	6 54	6 57	7 0	7 2	7 3	7 5	7 7	7 8	34
35	6 40	6 43	6 46	6 49	6 53	6 56	6 59	7 2	7 4	7 6	7 7	7 9	7 11	35
36	6 42	6 45	6 48	6 51	6 55	6 58	7 1	7 5	7 7	7 8	7 10	7 12	7 14	36
37	6 43	6 47	6 50	6 53	6 57	7 0	7 4	7 7	7 9	7 11	7 13	7 15	7 16	37
38	6 45	6 48	6 52	6 55	6 59	7 2	7 6	7 10	7 12	7 14	7 16	7 17	7 19	38
39	6 47	6 50	6 54	6 57	7 1	7 5	7 9	7 12	7 14	7 16	7 18	7 20	7 22	39
40	6 48	6 52	6 56	6 59	7 3	7 7	7 11	7 15	7 17	7 19	7 21	7 23	7 25	40
41	6 50	6 54	6 58	7 2	7 6	7 10	7 14	7 18	7 20	7 22	7 24	7 27	7 29	41
42	6 52	6 56	7 0	7 4	7 8	7 12	7 17	7 21	7 23	7 25	7 28	7 30	7 32	42
43	6 54	6 58	7 2	7 6	7 11	7 15	7 19	7 24	7 26	7 29	7 31	7 33	7 36	43
44	6 56	7 0	7 4	7 9	7 13	7 18	7 22	7 27	7 29	7 32	7 34	7 37	7 39	44
45	6 58	7 2	7 7	7 11	7 16	7 21	7 25	7 30	7 33	7 35	7 38	7 40	7 43	45
46	7 0	7 4	7 9	7 14	7 19	7 24	7 29	7 34	7 36	7 39	7 42	7 44	7 47	46
47	7 2	7 7	7 12	7 17	7 22	7 27	7 32	7 37	7 40	7 43	7 46	7 48	7 51	47
48	7 4	7 9	7 14	7 19	7 25	7 30	7 35	7 41	7 44	7 47	7 50	7 53	7 55	48
49	7 7	7 12	7 17	7 22	7 28	7 33	7 39	7 45	7 48	7 51	7 54	7 57	8 0	49
50	7 9	7 14	7 20	7 25	7 31	7 37	7 43	7 49	7 52	7 55	7 58	8 2	8 5	50
51	7 12	7 17	7 23	7 29	7 35	7 41	7 47	7 53	7 56	8 0	8 3	8 6	8 10	51
52	7 14	7 20	7 26	7 32	7 38	7 45	7 51	7 58	8 1	8 5	8 8	8 12	8 15	52
53	7 17	7 23	7 29	7 36	7 42	7 49	7 56	8 2	8 6	8 10	8 13	8 17	8 21	53
54	7 20	7 27	7 33	7 40	7 46	7 53	8 0	8 8	8 11	8 15	8 19	8 23	8 25	54
55	7 23	7 30	7 37	7 44	7 51	7 58	8 5	8 13	8 17	8 21	8 25	8 29	8 33	55
56	7 27	7 34	7 41	7 48	7 55	8 3	8 11	8 19	8 23	8 27	8 32	8 36	8 40	56
57	7 30	7 37	7 45	7 52	8 0	8 8	8 16	8 25	8 29	8 34	8 39	8 43	8 48	57
58	7 34	7 42	7 49	7 57	8 5	8 14	8 22	8 32	8 36	8 41	8 46	8 51	8 56	58
59	7 38	7 46	7 54	8 2	8 11	8 20	8 29	8 39	8 44	8 49	8 54	9 0	9 5	59
60	7 42	7 51	7 59	8 8	8 17	8 26	8 36	8 47	8 52	8 58	9 3	9 9	9 15	60

TABLE XXII.

Distance in Nautical Miles of the Sea Horizon uncorrected for effects of Refraction.*

Height.	Distance.	Height.	Distance.	Height.	Distance.	Height.	Distance.	Height.	Distance.	Height.	Distance.
Feet.	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.
1·1	1	390	21	1487	41	3293	61	9032	101	17608	141
3·5	2	428	22	1561	42	3513	63	9393	103	18111	143
8·0	3	468	23	1636	43	3740	65	9760	105	18622	145
14·2	4	510	24	1713	44	3974	67	10135	107	19140	147
22·1	5	550	25	1792	45	4213	69	10518	109	19664	149
31·9	6	598	26	1872	46	4461	71	10908	111	20197	151
43·3	7	645	27	1954	47	4716	73	11304	113	20736	153
56·6	8	694	28	2039	48	4976	75	11709	115	21282	155
71·7	9	744	29	2124	49	5249	77	12120	117	21836	157
88·5	10	797	30	2212	50	5524	79	12538	119	22397	159
107	11	850	31	2301	51	5808	81	12966	121	22964	161
127	12	906	32	2393	52	6098	83	13397	123	23540	163
149	13	964	33	2485	53	6394	85	13836	125	24121	165
173	14	1023	34	2581	54	6700	87	14282	127	24711	167
199	15	1084	35	2677	55	7012	89	14737	129	25307	169
226	16	1147	36	2775	56	7332	91	15197	131	25911	171
256	17	1211	37	2875	57	7656	93	15664	133	26521	173
287	18	1278	38	2977	58	7987	95	16139	135	27139	175
319	19	1346	39	3081	59	8330	97	16622	137	27764	177
354	20	1416	40	3186	60	8678	99	17111	139	28396	179

* The effects of refraction at low angles are very variable, but in ordinary cases, if the height of observer be supposed to be increased by one-third, the distance of the visible sea horizon will not exceed the tabular value corresponding to the revised entry. Extraordinary cases are those of mirage, &c., for which no general rule can be given.

TABLE XXIII.

NUMBER OF GEOGRAPHICAL MILES,* OR MINUTES OF THE EQUATOR CONTAINED IN A DEGREE OF LONGITUDE UNDER EACH PARALLEL OF LATITUDE.

Parallel of Latitude.	Length of Degree.	Parallel of Latitude.	Length of Degree.	Parallel of Latitude.	Length of Degree.	Parallel of Latitude.	Length of Degree.	Parallel of Latitude.	Length of Degree.	Parallel of Latitude.	Length of Degree.
°	′	°	′	°	′	°	′	°	′	°	′
0	60·000	16	57·690	31	51·475	46	41·750	61	29·161	76	14·560
1	59·991	17	57·394	32	50·930	47	40·992	62	28·240	77	13·539
2	59·964	18	57·081	33	50·370	48	40·220	63	27·310	78	12·514
3	59·918	19	56·751	34	49·793	49	39·437	64	26·372	79	11·485
4	59·800	20	56·403	35	49·202	50	38·642	65	25·426	80	10·452
5	59·773	21	56·038	36	48·596	51	37·834	66	24·471	81	9·416
6	59·673	22	55·657	37	47·975	52	37·015	67	23·509	82	8·377
7	59·556	23	55·258	38	47·339	53	36·185	68	22·540	83	7·336
8	59·419	24	54·842	39	46·688	54	35·343	69	21·564	84	6·292
9	59·266	25	54·410	40	46·021	55	34·490	70	20·581	85	5·246
10	59·093	26	53·962	41	45·346	56	33·627	71	19·592	86	4·199
11	58·905	27	53·496	42	44·654	57	32·754	72	18·596	87	3·150
12	58·697	28	53·015	43	43·948	58	31·870	73	17·595	88	2·101
13	58·472	29	52·518	44	43·229	59	30·977	74	16·588	89	1·050
14	58·229	30	52·004	45	42·495	60	30·074	75	15·577	90	0·000
15	57·968										

* To convert to Statute miles, multiply by 1·15.

TABLE XXIV.

Table for converting Statute into Geographical Miles.

Stat. Miles.	Geo. Miles.	Stat. Miles.	Geo. Miles.	Stat. Miles.	Geo. Miles.	Stat. Miles.	Geo. Miles.
1.00	0.87	13.25	11.49	25.50	22.12	37.75	32.75
1.25	1.08	13.50	11.71	25.75	22.34	38.00	32.97
1.50	1.30	13.75	11.93	26.00	22.56	38.25	33.18
1.75	1.52	14.00	12.15	26.25	22.77	38.50	33.40
2.00	1.74	14.25	12.36	26.50	22.99	38.75	33.61
2.25	1.95	14.50	12.58	26.75	23.22	39.00	33.83
2.50	2.17	14.75	12.79	27.00	23.42	39.25	34.04
2.75	2.39	15.00	13.01	27.25	23.63	39.50	34.26
3.00	2.60	15.25	13.22	27.50	23.85	39.75	34.48
3.25	2.82	15.50	13.44	27.75	24.07	40.00	34.70
3.50	3.04	15.75	13.66	28.00	24.29	40.25	34.91
3.75	3.26	16.00	13.88	28.25	24.50	40.50	35.13
4.00	3.47	16.25	14.09	28.50	24.72	40.75	35.35
4.25	3.68	16.50	14.31	28.75	24.94	41.00	35.57
4.50	3.90	16.75	14.53	29.00	25.16	41.25	35.78
4.75	4.12	17.00	14.75	29.25	25.37	41.50	36.00
5.00	4.34	17.25	14.97	29.50	25.59	41.75	36.22
5.25	4.56	17.50	15.19	29.75	25.81	42.00	36.44
5.50	4.77	17.75	15.40	30.00	26.03	42.25	36.65
5.75	4.99	18.00	15.62	30.25	26.24	42.50	36.87
6.00	5.21	18.25	15.83	30.50	26.46	42.75	37.08
6.25	5.42	18.50	16.05	30.75	26.67	43.00	37.30
6.50	5.64	18.75	16.26	31.00	26.89	43.25	37.51
6.75	5.85	19.00	16.48	31.25	27.10	43.50	37.73
7.00	6.07	19.25	16.69	31.50	27.32	43.75	37.94
7.25	6.29	19.50	16.91	31.75	27.54	44.00	38.17
7.50	6.51	19.75	17.13	32.00	27.76	44.25	38.38
7.75	6.72	20.00	17.35	32.25	27.97	44.50	38.60
8.00	6.94	20.25	17.56	32.50	28.19	44.75	38.82
8.25	7.15	20.50	17.78	32.75	28.41	45.00	39.04
8.50	7.37	20.75	18.00	33.00	28.63	45.25	39.25
8.75	7.59	21.00	18.22	33.25	28.84	45.50	39.47
9.00	7.81	21.25	18.43	33.50	29.06	45.75	39.68
9.25	8.03	21.50	18.65	33.75	29.28	46.00	39.91
9.50	8.25	21.75	18.87	34.00	29.50	46.25	40.12
9.75	8.47	22.00	19.09	34.25	29.71	46.50	40.34
10.00	8.68	22.25	19.30	34.50	29.93	46.75	40.55
10.25	8.89	22.50	19.52	34.75	30.14	47.00	40.77
10.50	9.11	22.75	19.73	35.00	30.36	47.25	40.98
10.75	9.32	23.00	19.95	35.25	30.57	47.50	41.20
11.00	9.54	23.25	20.16	35.50	30.79	47.75	41.42
11.25	9.75	23.50	20.38	35.75	31.01	48.00	41.64
11.50	9.97	23.75	20.60	36.00	31.23	48.25	41.85
11.75	10.19	24.00	20.82	36.25	31.44	48.50	42.07
12.00	10.41	24.25	21.03	36.50	31.66	48.75	42.29
12.25	10.62	24.50	21.25	36.75	31.88	49.00	42.51
12.50	10.84	24.75	21.47	37.00	32.10	49.25	42.72
12.75	11.06	25.00	21.69	37.25	32.31	49.50	42.94
13.00	11.28	25.25	21.90	37.50	32.53	49.75	43.16
						50.00	43.38

TABLE XXV.

For converting Geographical into Statute Miles.

Geo. Miles.	Stat. Miles.	Geo. Miles.	Stat. Miles.	Geo. Miles.	Stat. Miles.	Geo. Miles.	Stat. Miles.
1.00	1.15	13.25	15.26	25.50	29.39	37.75	43.51
1.25	1.44	13.50	15.54	25.75	29.68	38.00	43.80
1.50	1.73	13.75	15.83	26.00	29.97	38.25	44.09
1.75	2.02	14.00	16.14	26.25	30.25	38.50	44.38
2.00	2.31	14.25	16.42	26.50	30.54	38.75	44.67
2.25	2.59	14.50	16.71	26.75	30.83	39.00	44.96
2.50	2.88	14.75	17.00	27.00	31.12	39.25	45.24
2.75	3.17	15.00	17.29	27.25	31.41	39.50	45.53
3.00	3.46	15.25	17.57	27.50	31.70	39.75	45.82
3.25	3.74	15.50	17.86	27.75	31.99	40.00	46.11
3.50	4.03	15.75	18.15	28.00	32.28	40.25	46.39
3.75	4.32	16.00	18.44	28.25	32.56	40.50	46.68
4.00	4.61	16.25	18.73	28.50	32.85	40.75	46.97
4.25	4.89	16.50	19.02	28.75	33.14	41.00	47.26
4.50	5.18	16.75	19.31	29.00	33.43	41.25	47.54
4.75	5.47	17.00	19.60	29.25	33.71	41.50	47.83
5.00	5.76	17.25	19.88	29.50	34.00	41.75	48.11
5.25	6.05	17.50	20.17	29.75	34.29	42.00	48.41
5.50	6.34	17.75	20.46	30.00	34.58	42.25	48.70
5.75	6.63	18.00	20.75	30.25	34.86	42.50	48.99
6.00	6.92	18.25	21.03	30.50	35.15	42.75	49.28
6.25	7.20	18.50	21.32	30.75	35.44	43.00	49.57
6.50	7.49	18.75	21.61	31.00	35.73	43.25	49.85
6.75	7.78	19.00	21.90	31.25	36.02	43.50	50.14
7.00	8.07	19.25	22.18	31.50	36.31	43.75	50.43
7.25	8.35	19.50	22.47	31.75	36.60	44.00	50.72
7.50	8.64	19.75	22.76	32.00	36.89	44.25	51.00
7.75	8.93	20.00	23.05	32.25	37.17	44.50	51.29
8.00	9.22	20.25	23.34	32.50	37.46	44.75	51.58
8.25	9.50	20.50	23.63	32.75	37.75	45.00	51.87
8.50	9.79	20.75	23.92	33.00	38.04	45.25	52.16
8.75	10.08	21.00	24.21	33.25	38.32	45.50	52.45
9.00	10.37	21.25	24.49	33.50	38.61	45.75	52.74
9.25	10.66	21.50	24.78	33.75	38.90	46.00	53.03
9.50	10.95	21.75	25.07	34.00	39.19	46.25	53.31
9.75	11.24	22.00	25.36	34.25	39.48	46.50	53.60
10.00	11.53	22.25	25.64	34.50	39.77	46.75	53.89
10.25	11.81	22.50	25.93	34.75	40.06	47.00	54.18
10.50	12.10	22.75	26.22	35.00	40.35	47.25	54.46
10.75	12.39	23.00	26.51	35.25	40.63	47.50	54.75
11.00	12.68	23.25	26.80	35.50	40.92	47.75	55.04
11.25	12.96	23.50	27.09	35.75	41.21	48.00	55.33
11.50	13.25	23.75	27.38	36.00	41.50	48.25	55.61
11.75	13.54	24.00	27.67	36.25	41.78	48.50	55.90
12.00	13.83	24.25	27.95	36.50	42.07	48.75	56.19
12.25	14.12	24.50	28.24	36.75	42.36	49.00	56.48
12.50	14.41	24.75	28.53	37.00	42.65	49.25	56.77
12.75	14.70	25.00	28.82	37.25	42.93	49.50	57.06
13.00	14.99	25.25	29.10	37.50	43.22	49.75	57.35
						50.00	57.64

TABLE XXVI.

Comparison of Thermometer Scales.

Fahrenheit.	Réaumur.	Centigrade.	Fahrenheit.	Réaumur.	Centigrade.	Fahrenheit.	Réaumur.	Centigrade.
°	°	°	°	°	°	°	°	°
			33	+0·4	+ 0·6	67	+15·6	+19·4
0	−14·2	−17·8	34	0·9	1·1	68	16·0	20·0
1	13·8	17·2	35	1·3	1·7	69	16·4	20·6
2	13·3	16·7	36	1·8	2·2	70	16·9	21·1
3	12·9	16·1	37	2·2	2·8	71	17·3	21·7
4	12·4	15·6	38	2·7	3·3	72	17·8	22·2
5	12·0	15·0	39	3·1	3·9	73	18·2	22·8
6	11·6	14·4	40	3·6	4·4	74	18·7	23·3
7	11·1	13·9	41	4·0	5·0	75	19·1	23·9
8	10·7	13·3	42	4·4	5·6	76	19·6	24·4
9	10·2	12·8	43	4·9	6·1	77	20·0	25·0
10	9·8	12·2	44	5·3	6·7	78	20·4	25·6
11	9·3	11·7	45	5·8	7·2	79	20·9	26·1
12	8·9	11·1	46	6·2	7·8	80	21·3	26·7
13	8·4	10·6	47	6·7	8·3	81	21·8	27·2
14	8·0	10·0	48	7·1	8·9	82	22·2	27·8
15	7·6	9·4	49	7·6	9·4	83	22·7	28·3
16	7·1	8·9	50	8·0	10·0	84	23·1	28·9
17	6·7	8·3	51	8·4	10·6	85	23·6	29·4
18	6·2	7·8	52	8·9	11·1	86	24·0	30·0
19	5·8	7·2	53	9·3	11·7	87	24·4	30·6
20	5·3	6·7	54	9·8	12·2	88	24·9	31·1
21	4·9	6·1	55	10·2	12·8	89	25·3	31·7
22	4·4	5·6	56	10·7	13·3	90	25·8	32·2
23	4·0	5·0	57	11·1	13·9	91	26·2	32·8
24	3·6	4·4	58	11·6	14·4	92	26·7	33·3
25	3·1	3·9	59	12·0	15·0	93	27·1	33·9
26	2·7	3·3	60	12·4	15·6	94	27·6	34·4
27	2·2	2·8	61	12·9	16·1	95	28·0	35·0
28	1·8	2·2	62	13·3	16·7	96	28·4	35·6
29	1·3	1·7	63	13·8	17·2	97	28·9	36·1
30	0·9	1·1	64	14·2	17·8	98	29·3	36·7
31	−0·4	−0·6	65	14·7	18·3	99	29·8	37·2
32	0·0	0·0	66	+15·1	+18·9	100	+30·2	+37·8

$x°$ Réaumur $= (32° + \frac{9}{4} x°)$ Fahrenheit $= \frac{5}{4} x°$ Centigrade.

$x°$ Centigrade $= (32° + \frac{9}{5} x°)$ Fahrenheit $= \frac{4}{5} x°$ Réaumur.

$x°$ Fahrenheit $= \frac{4}{9} (x° - 32)$ Réaumur $= \frac{5}{9} (x° - 32°)$ Centigrade.

TABLE XXVII.

For converting English Inches and Tenths into Millimètres.

English inches and tenths.	Millim.	English inches and tenths.	Millim.	English inches and tenths.	Millim.	English inches and tenths.	Millim.	English inches and tenths.	Millim.
12·0	304·79	16·0	406·39	20·0	507·99	24·0	609·59	28·0	711·19
1	307·33	1	408·93	1	510·53	1	612·13	1	713·73
2	309·87	2	411·47	2	513·07	2	614·67	2	716·27
3	312·41	3	414·01	3	515·61	3	617·21	3	718·81
4	314·95	4	416·55	4	518·15	4	619·75	4	721·35
5	317·49	5	419·09	5	520·69	5	622·29	5	723·89
6	320·03	6	421·63	6	523·23	6	624·83	6	726·43
7	322·57	7	424·17	7	525·77	7	627·37	7	728·97
8	325·11	8	426·71	8	528·31	8	629·91	8	731·51
9	327·65	9	429·25	9	530·85	9	632·45	9	734·05
13·0	330·19	17·0	431·79	21·0	533·39	25·0	634·99	29·0	736·59
1	332·73	1	434·33	1	535·93	1	637·53	1	739·13
2	335·27	2	436·87	2	538·47	2	640·07	2	741·67
3	337·81	3	439·41	3	541·01	3	642·61	3	744·21
4	340·35	4	441·95	4	543·55	4	645·15	4	746·75
5	342·89	5	444·49	5	546·09	5	647·69	5	749·29
6	345·43	6	447·03	6	548·63	6	650·23	6	751·83
7	347·97	7	449·57	7	551·17	7	652·77	7	754·37
8	350·51	8	452·11	8	553·71	8	655·31	8	756·91
9	353·05	9	454·65	9	556·25	9	657·85	9	759·45
14·0	355·59	18·0	457·19	22·0	558·79	26·0	660·39	30·0	761·99
1	358·13	1	459·73	1	561·33	1	662·93	1	764·53
2	360·67	2	462·27	2	563·87	2	665·47	2	767·07
3	363·21	3	464·81	3	566·41	3	668·01	3	769·61
4	365·75	4	467·35	4	568·95	4	670·55	4	772·15
5	368·29	5	469·89	5	571·49	5	673·09	5	774·69
6	370·83	6	472·43	6	574·03	6	675·63	6	777·23
7	373·37	7	474·97	7	576·57	7	678·17	7	779·77
8	375·91	8	477·51	8	579·11	8	680·71	8	782·31
9	378·45	9	480·05	9	581·65	9	683·25	9	784·85
15·0	380·99	19·0	482·59	23·0	584·19	27·0	685·79	31·0	787·39
1	383·53	1	485·13	1	586·73	1	688·33	1	789·93
2	386·07	2	487·67	2	589·27	2	690·87	2	792·47
3	388·61	3	490·21	3	591·81	3	693·41	3	795·01
4	391·15	4	492·75	4	594·35	4	695·95	4	797·55
5	393·69	5	495·29	5	596·89	5	698·49		
6	396·23	6	497·83	6	599·43	6	701·03		
7	398·77	7	500·37	7	601·97	7	703·57		
8	401·31	8	502·91	8	604·51	8	706·11		
9	403·85	9	505·45	9	607·05	9	708·65		

Parts to be added for Hundredths of an Inch.

1	2	3	4	5	6	7	8	9
·254	·508	·762	1·016	1·270	1·524	1·778	2·032	2·286

TABLE XXVIII.

CONVERSION OF MÈTRES INTO ENGLISH FEET.

·1 to 210.

Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.
1	3·28	36	118·11	71	232·94	106	347·78	141	462·61	176	577·44
2	6·56	37	121·39	72	236·22	7	351·06	42	465·89	77	580·72
3	9·84	38	124·67	73	239·51	8	354·34	43	469·17	78	584·00
4	13·12	39	127·96	74	242·79	9	357·62	44	472·45	79	587·28
5	16·40	40	131·24	75	246·07	10	360·90	45	475·73	80	590·56
6	19·69	41	134·52	76	249·35	111	364·18	146	479·01	181	593·84
7	22·97	42	137·80	77	252·63	12	367·46	47	482·29	82	597·12
8	26·25	43	141·08	78	255·91	13	370·74	48	485·57	83	600·40
9	29·53	44	144·36	79	259·19	14	374·02	49	488·85	84	603·69
10	32·81	45	147·64	80	262·47	15	377·30	50	492·13	85	606·97
11	36·09	46	150·92	81	265·75	116	380·58	151	495·42	186	610·25
12	39·37	47	154·20	82	269·03	17	383·87	52	498·70	87	613·53
13	42·65	48	157·48	83	272·31	18	387·15	53	501·98	88	616·81
14	45·93	49	160·76	84	275·60	19	390·43	54	505·26	89	620·09
15	49·21	50	164·04	85	278·88	20	393·71	55	508·54	90	623·37
16	52·49	51	167·33	86	282·16	121	396·99	156	511·82	191	626·65
17	55·78	52	170·61	87	285·44	22	400·27	57	515·10	92	629·93
18	59·06	53	173·89	88	288·72	23	403·55	58	518·38	93	633·21
19	62·34	54	177·17	89	292·00	24	406·83	59	521·66	94	636·49
20	65·62	55	180·45	90	295·28	25	410·11	60	524·94	95	639·78
21	68·90	56	183·73	91	298·56	126	413·39	161	528·22	196	643·06
22	72·18	57	187·01	92	301·84	27	416·67	62	531·51	97	646·34
23	75·46	58	190·29	93	305·12	28	419·96	63	534·79	98	649·62
24	78·74	59	193·57	94	308·40	29	423·24	64	538·07	99	652·90
25	82·02	60	196·85	95	311·69	30	426·52	65	541·35	200	656·18
26	85·30	61	200·13	96	314·97	131	429·80	166	544·63	201	659·46
27	88·58	62	203·42	97	318·25	32	433·08	67	547·91	2	662·74
28	91·87	63	206·70	98	321·53	33	436·36	68	551·19	3	666·02
29	95·15	64	209·98	99	324·81	34	439·64	69	554·47	4	669·30
30	98·43	65	213·26	100	328·09	35	442·92	70	557·75	5	672·58
31	101·71	66	216·54	101	331·37	136	446·20	171	561·03	206	675·87
32	104·99	67	219·82	2	334·65	37	449·48	72	564·31	7	679·15
33	108·27	68	223·10	3	337·93	38	452·76	73	567·60	8	682·43
34	111·55	69	226·38	4	341·21	39	456·04	74	570·88	9	685·71
35	114·83	70	229·66	5	344·49	40	459·33	75	574·16	10	688·99

TABLE XXVIII.—(*continued*).

Conversion of Mètres into English Feet.

211 to 420.

Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.
211	692·27	246	807·10	281	921·93	316	1036·76	351	1151·60	386	1266·43
12	695·55	47	810·38	82	925·21	17	1040·05	52	1154·88	87	1269·71
13	698·83	48	813·66	83	928·49	18	1043·33	53	1158·16	88	1272·99
14	702·11	49	816·94	84	931·78	19	1046·61	54	1161·44	89	1276·2[illegible]
15	705·39	50	820·22	85	935·06	20	1049·89	55	1164·72	90	1279·55
216	708·67	251	823·51	286	938·34	321	1053·17	356	1168·00	391	1282·83
17	711·96	52	826·79	87	941·62	22	1056·45	57	1171·28	92	1286·11
18	715·24	53	830·07	88	944·90	23	1059·73	58	1174·56	93	1289·39
19	718·52	54	833·35	89	948·18	24	1063·01	59	1177·84	94	1292·67
20	721·80	55	836·63	90	951·46	25	1066·29	60	1181·12	95	1295·95
221	725·08	256	839·91	291	954·74	326	1069·57	361	1184·40	396	1299·23
22	728·36	57	843·19	92	958·02	27	1072·85	62	1187·69	97	1302·52
23	731·64	58	846·47	93	961·30	28	1076·13	63	1190·97	98	1305·80
24	734·92	59	849·75	94	964·58	29	1079·42	64	1194·25	99	1309·08
25	738·20	60	853·03	95	967·87	30	1082·70	65	1197·53	400	1312·36
226	741·48	261	856·31	296	971·15	331	1085·98	366	1200·81	401	1315·64
27	744·76	62	859·60	97	974·43	32	1089·26	67	1204·09	2	1318·92
28	748·05	63	862·88	98	977·71	33	1092·54	68	1207·37	3	1322·20
29	751·33	64	866·16	99	980·99	34	1095·82	69	1210·65	4	1325·48
30	754·61	65	869·44	300	984·27	35	1099·10	70	1213·93	5	1328·76
231	757·89	266	872·72	301	987·55	336	1102·38	371	1217·21	406	1332·05
32	761·17	67	876·00	2	990·83	37	1105·66	72	1220·49	7	1335·33
33	764·45	68	879·28	3	994·11	38	1108·94	73	1223·78	8	1338·61
34	767·73	69	882·56	4	997·39	39	1112·22	74	1227·06	9	1341·89
35	771·01	70	885·84	5	1000·67	40	1115·51	75	1230·34	10	1345·17
236	774·29	271	889·12	306	1003·96	341	1118·79	376	1233·62	411	1348·45
37	777·57	72	892·40	7	1007·24	42	1122·07	77	1236·90	12	1351·73
38	780·85	73	895·69	8	1010·52	43	1125·35	78	1240·18	13	1355·01
39	784·13	74	898·97	9	1013·80	44	1128·63	79	1243·46	14	1358·29
40	787·42	75	902·25	10	1017·08	45	1131·91	80	1246·74	15	1361·57
241	790·70	276	905·53	311	1020·36	346	1135·19	381	1250·02	416	1364·85
42	793·98	77	908·81	12	1023·64	47	1138·47	82	1253·30	17	1368·13
43	797·26	78	912·09	13	1026·92	48	1141·75	83	1256·58	18	1371·42
44	800·54	79	915·37	14	1030·20	49	1145·03	84	1259·87	19	1374·70
45	803·82	80	918·65	15	1033·48	50	1148·31	85	1263·15	20	1377·98

TABLE XXVIII.—(*continued*).

Conversion of Mètres into English Feet.

421 to 630.

Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.
421	1381·26	456	1496·09	491	1610·92	526	1725·75	561	1840·58	596	1955·42
22	1384·54	57	1499·37	92	1614·20	27	1729·03	62	1843·87	97	1958·70
23	1387·82	58	1502·65	93	1617·48	28	1732·31	63	1847·15	98	1961·98
24	1391·10	59	1505·93	94	1620·76	29	1735·60	64	1850·43	99	1965·26
25	1394·38	60	1509·21	95	1624·05	30	1738·88	65	1853·71	600	1968·54
426	1397·66	461	1512·49	496	1627·33	531	1742·16	566	1856·99	601	1971·82
27	1400·94	62	1515·78	97	1630·61	32	1745·44	67	1860·27	2	1975·10
28	1404·22	63	1519·06	98	1633·89	33	1748·72	68	1863·55	3	1978·38
29	1407·51	64	1522·34	99	1637·17	34	1752·00	69	1866·83	4	1981·66
30	1410·79	65	1525·62	500	1640·45	35	1755·28	70	1870·11	5	1984·94
431	1414·07	466	1528·90	501	1643·73	536	1758·56	571	1873·39	606	1988·22
32	1417·35	67	1532·18	2	1647·01	37	1761·84	72	1876·67	7	1991·51
33	1420·63	68	1535·46	3	1650·29	38	1765·12	73	1879·95	8	1994·79
34	1423·91	69	1538·74	4	1653·57	39	1768·40	74	1883·23	9	1998·07
35	1427·19	70	1542·02	5	1656·85	40	1771·69	75	1886·52	10	2001·35
436	1430·47	471	1545·30	506	1660·13	541	1774·97	576	1889·80	611	2004·63
37	1433·75	72	1548·58	7	1663·42	42	1778·25	77	1893·08	12	2007·91
38	1437·03	73	1551·87	8	1666·70	43	1781·53	78	1896·36	13	2011·19
39	1440·31	74	1555·15	9	1669·98	44	1784·81	79	1899·64	14	2014·47
40	1443·60	75	1558·43	10	1673·26	45	1788·09	80	1902·92	15	2017·75
441	1446·88	476	1561·71	511	1676·54	546	1791·37	581	1906·20	616	2021·03
42	1450·16	77	1564·99	12	1679·82	47	1794·65	82	1909·48	17	2024·31
43	1453·44	78	1568·27	13	1683·10	48	1797·93	83	1912·76	18	2027·60
44	1456·72	79	1571·55	14	1686·38	49	1801·21	84	1916·05	19	2030·88
45	1460·00	80	1574·83	15	1689·66	50	1804·49	85	1919·33	20	2034·16
446	1463·28	481	1578·11	516	1692·94	551	1807·78	586	1922·61	621	2037·44
47	1466·56	82	1581·39	17	1696·22	52	1811·06	87	1925·89	22	2040·72
48	1469·84	83	1584·67	18	1699·51	53	1814·34	88	1929·17	23	2044·00
49	1473·12	84	1587·96	19	1702·79	54	1817·62	89	1932·45	24	2047·28
50	1476·40	85	1591·23	20	1706·07	55	1820·90	90	1935·73	25	2050·56
451	1479·69	486	1594·52	521	1709·35	556	1824·18	591	1939·01	626	2053·84
52	1482·97	87	1597·80	22	1712·63	57	1827·46	92	1942·29	27	2057·12
53	1486·25	88	1601·08	23	1715·91	58	1830·74	93	1945·57	28	2060·40
54	1489·53	89	1604·36	24	1719·19	59	1834·02	94	1948·85	29	2063·69
55	1492·81	90	1607·64	25	1722·47	60	1837·30	95	1952·13	30	2066·97

TABLE XXVIII.—(*continued*).

CONVERSION OF MÈTRES INTO ENGLISH FEET.

631 to 840.

Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.
631	2070·25	666	2185·08	701	2299·91	736	2414·74	771	2529·57	806	2644·40
32	2073·53	67	2188·36	2	2303·19	37	2418·02	72	2532·85	7	2647·69
33	2076·81	68	2191·64	3	2306·47	38	2421·30	73	2536·13	8	2650·97
34	2080·09	69	2194·92	4	2309·75	39	2424·58	74	2539·42	9	2654·25
35	2083·37	70	2198·20	5	2313·03	40	2427·87	75	2542·70	10	2657·53
636	2086·65	671	2201·48	706	2316·31	741	2431·15	776	2545·98	811	2660·81
37	2089·93	72	2204·76	7	2319·60	42	2434·43	77	2549·26	12	2664·09
38	2093·21	73	2208·05	8	2322·88	43	2437·71	78	2552·54	13	2667·37
39	2096·49	74	2211·33	9	2326·16	44	2440·99	79	2555·82	14	2670·65
40	2099·78	75	2214·61	10	2329·44	45	2444·27	80	2559·10	15	2673·93
641	2103·06	676	2217·89	711	2332·72	746	2447·55	781	2562·38	816	2677·21
42	2106·34	77	2221·17	12	2336·00	47	2450·83	82	2565·66	17	2680·49
43	2109·62	78	2224·45	13	2339·28	48	2454·11	83	2568·94	18	2683·78
44	2112·90	79	2227·73	14	2342·56	49	2457·39	84	2572·22	19	2687·06
45	2116·18	80	2231·01	15	2345·84	50	2460·67	85	2575·51	20	2690·34
646	2119·46	681	2234·29	716	2349·12	751	2463·96	786	2578·79	821	2693·62
47	2122·74	82	2237·57	17	2352·40	52	2467·24	87	2582·07	22	2696·90
48	2126·02	83	2240·85	18	2355·69	53	2470·52	88	2585·35	23	2700·18
49	2129·30	84	2244·13	19	2358·97	54	2473·80	89	2588·63	24	2703·46
50	2132·58	85	2247·42	20	2362·25	55	2477·08	90	2591·91	25	2706·74
651	2135·87	686	2250·70	721	2365·53	756	2480·36	791	2595·19	826	2710·02
52	2139·15	87	2253·98	22	2368·81	57	2483·64	92	2598·47	27	2713·30
53	2142·43	88	2257·26	23	2372·09	58	2486·92	93	2601·75	28	2716·58
54	2145·71	89	2260·54	24	2375·37	59	2490·20	94	2605·03	29	2719·87
55	2148·99	90	2263·82	25	2378·65	60	2493·48	95	2608·31	30	2723·15
656	2152·27	691	2267·10	726	2381·93	761	2496·76	796	2611·60	831	2726·43
57	2155·55	92	2270·38	27	2385·21	62	2500·05	97	2614·88	32	2729·71
58	2158·83	93	2273·66	28	2388·49	63	2503·33	98	2618·16	33	2732·99
59	2162·11	94	2276·94	29	2391·78	64	2506·61	99	2621·44	34	2736·27
60	2165·39	95	2280·22	30	2395·06	65	2509·89	800	2624·72	35	2739·55
661	2168·67	696	2283·51	731	2398·34	766	2513·17	801	2628·00	836	2742·83
62	2171·96	97	2286·79	32	2401·62	67	2516·45	2	2631·28	37	2746·11
63	2175·24	98	2290·07	33	2404·90	68	2519·73	3	2634·56	38	2749·39
64	2178·52	99	2293·35	34	2408·18	69	2523·01	4	2637·84	39	2752·67
65	2181·80	700	2296·63	35	2411·46	70	2526·29	5	2641·12	40	2755·96

TABLE XXVIII.—(*continued*).

Conversion of Mètres into English Feet.

841 to 1000.

Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.	Mètres	Feet.
841	2759·24	871	2857·66	901	2956·09	926	3038·11	951	3120·14	976	3202·16
42	2762·52	72	2860·94	2	2959·37	27	3041·39	52	3123·42	77	3205·44
43	2765·80	73	2864·22	3	2962·65	28	3044·67	53	3126·70	78	3208·72
44	2769·08	74	2867·51	4	2965·93	29	3047·96	54	3129·98	79	3212·00
45	2772·36	75	2870·79	5	2969·21	30	3051·24	55	3133·26	80	3215·28
846	2775·64	876	2874·07	906	2972·49	931	3054·52	956	3136·54	981	3218·56
47	2778·92	77	2877·35	7	2975·78	32	3057·80	57	3139·82	82	3221·84
48	2782·20	78	2880·63	8	2979·06	33	3061·08	58	3143·10	83	3225·12
49	2785·48	79	2883·91	9	2982·34	34	3064·36	59	3146·38	84	3228·40
50	2788·76	80	2887·19	10	2985·62	35	3067·64	60	3149·66	85	3231·69
851	2792·05	881	2890·47	911	2988·90	936	3070·92	961	3152·94	986	3254·97
52	2795·33	82	2893·75	12	2992·18	37	3074·20	62	3156·22	87	3238·25
53	2798·61	83	2897·03	13	2995·46	38	3077·48	63	3159·51	88	3241·53
54	2801·89	84	2900·31	14	2998·74	39	3080·76	64	3162·79	89	3244·81
55	2805·17	85	2903·60	15	3002·02	40	3084·05	65	3166·07	90	3248·09
856	2808·45	886	2906·88	916	3005·30	941	3087·33	966	3169·35	991	3251·37
57	2811·73	87	2910·16	17	3008·58	42	3090·61	67	3172·63	92	3254·65
58	2815·01	88	2913·44	18	3011·87	43	3093·89	68	3175·91	93	3257·93
59	2818·29	89	2916·72	19	3015·15	44	3097·17	69	3179·19	94	3261·21
60	2821·57	90	2920·00	20	3018·43	45	3100·45	70	3182·47	95	3264·49
861	2824·85	891	2923·28	921	3021·71	946	3103·73	971	3185·75	996	3267·78
62	2828·14	92	2926·56	22	3024·99	47	3107·01	72	3189·03	97	3271·06
63	2831·42	93	2929·84	23	3028·27	48	3110·29	73	3192·31	98	3274·34
64	2834·70	94	2933·12	24	3031·55	49	3113·57	74	3195·60	99	3277·62
65	2837·98	95	2936·40	25	3034·83	50	3116·85	75	3198·88	1000	3280·90
866	2841·26	896	2939·69								
67	2844·54	97	2942·97								
68	2847·82	98	2946·25								
69	2851·10	99	2949·53								
70	2854·38	900	2952·81								

TABLE XXIX.

Conversion of Kilomètres into English Statute Miles.

Kilo-mètres.	English Statute Miles.	Kilo-mètres.	English Statute Miles.	Kilo-mètres.	English Statute Miles.	Kilo-mètres.	English Statute Miles.	Kilo-mètres.	English Statute Miles.
1	0·62	21	13·05	41	25·48	61	37·90	81	50·33
2	1·24	22	13·67	42	26·10	62	38·53	82	50·95
3	1·86	23	14·29	43	26·72	63	39·15	83	51·57
4	2·49	24	14·91	44	27·34	64	39·77	84	52·20
5	3·11	25	15·53	45	27·96	65	40·39	85	52·82
6	3·73	26	16·16	46	28·58	66	41·01	86	53·44
7	4·35	27	16·78	47	29·21	67	41·63	87	54·06
8	4·97	28	17·50	48	29·83	68	42·25	88	54·68
9	5·59	29	18·02	49	30·45	69	42·88	89	55·30
10	6·21	30	18·64	50	31·07	70	43·50	90	55·92
11	6·84	31	19·26	51	31·69	71	44·12	91	56·55
12	7·46	32	19·88	52	32·31	72	44·74	92	57·17
13	8·08	33	20·51	53	32·93	73	45·36	93	57·79
14	8·70	34	21·13	54	33·55	74	45·98	94	58·41
15	9·32	35	21·75	55	34·18	75	46·60	95	59·03
16	9·94	36	22·37	56	34·90	76	47·23	96	59·65
17	10·56	37	22·99	57	35·42	77	47·85	97	60·27
18	11·18	38	23·61	58	36·04	78	48·47	98	60·90
19	11·81	39	24·23	59	36·66	79	49·09	99	61·52
20	12·43	40	24·86	60	37·28	80	49·71	100	62·14
100	62·14	300	186·42	500	310·69	700	434·97	900	559·24
200	124·28	400	248·55	600	372·83	800	497·11	1000	621·38
1000	621·38	3000	1864·15	5000	3106·91	7000	4349·68	9000	5592·44
2000	1242·77	4000	2485·53	6000	3728·30	8000	4971·06	10,000	6213·82

TABLE XXX.

Conversion of Russian Versts into English Statute Miles.

Versts.	English Statute Miles.	Versts.	English Statute Miles.	Versts.	English Statute Miles.	Versts.	English Statute Miles.	Versts.	English Statute Miles.
1	0·66	21	13·92	41	27·18	61	40·44	81	53·69
2	1·33	22	14·58	42	27·84	62	41·10	82	54·36
3	1·99	23	15·25	43	28·50	63	41·76	83	55·02
4	2·65	24	15·91	44	29·17	64	42·42	84	55·68
5	3·31	25	16·57	45	29·83	65	43·09	85	56·34
6	3·98	26	17·23	46	30·49	66	43·75	86	57·01
7	4·64	27	17·90	47	31·16	67	44·41	87	57·67
8	5·30	28	18·56	48	31·82	68	45·08	88	58·33
9	5 97	29	19·22	49	32·48	69	45·74	89	59·00
10	6·63	30	19·89	50	33·14	70	46·40	90	59·66
11	7·29	31	20·55	51	33·81	71	47·06	91	60 32
12	7·95	32	21·21	52	34·47	72	47·73	92	60·98
13	8·62	33	21·88	53	35·13	73	48·39	93	61·65
14	9·28	34	22·54	54	35·80	74	49·05	94	62·31
15	9·94	35	23·20	55	36·46	75	49·72	95	62·97
16	10·61	36	23·86	56	37·12	76	50·38	96	63·64
17	11·27	37	24·53	57	37·78	77	51·04	97	64·30
18	11·93	38	25·19	58	38·45	78	51·70	98	64·96
19	12·59	39	25·85	59	39·11	79	52·37	99	65·63
20	13·26	40	26·52	60	39·77	80	53·03	100	66·29
100	66·29	300	198·86	500	231·44	700	464·02	900	596·59
200	132·58	400	265·15	600	397·73	800	530·30	1000	666·88
1000	662·88	3000	1988·64	5000	3314·39	7000	4640 15	9000	5965·91
2000	1325·76	4000	2651·52	6000	3977·27	8000	5303·03	10,000	6628·79

TABLE XXXI.

Foreign Moneys.

With Equivalents in British Currency.

Country.	*Principal Coins.*	Sterling. *s.*	*d.*
Austria	100 new kreuzers = 1 florin	1	8
Belgium	100 centimes = 1 franc	0	9½
Canada, etc.	100 cents = 1 dollar	4	0
China	1600—1700 copper cash = 1 Haikwan tael	4	10½
Denmark	100 öre = 1 Krone	1	1⅓
France	100 centimes = 1 franc	0	9½
	Milliard = f. 1000 mills. = £40,000,000.		
Germany	North German or Prussian thaler	3	0
	South German florin	1	8
	Imperial Reichsmark = 100 Pfennige	1	0
	Imperial gold piece of 20 marks	20	0
Greece	100 lepta = 1 drachma	0	9½
Holland	100 cents or 20 stivers = 1 florin	1	8
India	192 pie = 64 pice = 16 annas = 1 rupee	about 1	3
	The lac is 100,000 rupees.		
Italy	100 centesimi = 1 lira	0	9½
Norway	100 öre = 1 Krone	1	1⅓
Portugal	1000 Reis = 1 milrei	4	5
Russia	100 copecs = 1 silver rouble	3	2
Spain	100 centisimos = 1 peseta = 4 reales	0	9½
Sweden	100 öre = 1 Krone	1	1⅓
Switzerland	100 rappen or centimes = 1 franc	0	9½
Turkey	100 piastre = 1 lira, *variable*	about 18	0¾
United States	100 cents = 1 dollar ($) *in gold*	4	1
	10 dollars = 1 eagle	41	1

TABLE XXXII.

Angles subtended by a 10-ft. Rod at Distances from 50 to 1500 Feet.

Feet.	Angle.			Feet.	Angle.			Feet.	Angle.			Feet.	Angle.			Feet.	Angle.		
	°	′	″		°	′	″		°	′	″		°	′	″		°	′	″
50	11	27	33	97	5	54	24	144	3	58	44	191	2	59	59	276	2	4	33
51	11	14	4	98	5	50	47	145	3	57	5	192	2	59	3	278	2	3	39
52	11	1	7	99	5	47	15	146	3	55	28	193	2	58	7	280	2	2	46
53	10	48	38	100	5	43	46	147	3	53	51	194	2	57	12	282	2	1	54
54	10	36	34	101	5	40	27	148	3	52	17	195	2	56	18	284	2	1	2
55	10	25	3	102	5	37	32	149	3	50	43	196	2	55	23	286	2	0	12
56	10	13	53	103	5	33	45	150	3	49	11	197	2	54	36	288	1	59	22
57	10	3	7	104	5	30	33	151	3	47	38	198	2	53	37	290	1	58	32
58	9	52	43	105	5	27	24	152	3	46	10	199	2	52	49	292	1	57	44
59	9	42	40	106	5	24	19	153	3	44	41	200	2	51	53	294	1	56	55
60	9	32	58	107	5	21	17	154	3	43	12	202	2	50	13	296	1	56	8
61	9	23	34	108	5	18	17	155	3	41	47	204	2	48	46	298	1	55	21
62	9	14	28	109	5	15	23	156	3	40	22	206	2	46	47	300	1	54	35
63	9	5	42	110	5	12	31	157	3	38	58	208	2	45	16	302	1	53	49
64	8	57	9	111	5	9	42	158	3	37	34	210	2	43	42	304	1	53	5
65	8	48	53	112	5	6	56	159	3	36	12	212	2	42	9	306	1	52	20
66	8	40	52	113	5	4	13	160	3	34	51	214	2	40	38	308	1	51	36
67	8	33	6	114	5	1	33	161	3	33	31	216	2	39	8	310	1	50	53
68	8	25	33	115	4	58	56	162	3	32	12	218	2	37	41	312	1	50	11
69	8	18	13	116	4	56	21	163	3	30	54	220	2	36	16	314	1	49	29
70	8	11	7	117	4	53	50	164	3	29	37	222	2	34	51	316	1	48	47
71	8	4	11	118	4	51	20	165	3	28	21	224	2	33	28	318	1	48	6
72	7	57	28	119	4	48	57	166	3	27	5	226	2	32	6	320	1	47	25
73	7	50	56	120	4	46	29	167	3	25	52	228	2	30	46	322	1	46	45
74	7	44	34	121	4	44	6	168	3	24	38	230	2	29	28	324	1	46	6
75	7	38	22	122	4	41	47	169	3	23	25	232	2	28	10	326	1	45	27
76	7	32	20	123	4	39	29	170	3	22	13	234	2	26	55	328	1	44	48
77	7	26	28	124	4	37	14	171	3	21	2	236	2	25	40	330	1	44	10
78	7	20	44	125	4	35	1	172	3	19	52	238	2	24	28	332	1	43	32
79	7	15	9	126	4	32	51	173	3	18	13	240	2	23	14	334	1	42	56
80	7	9	43	127	4	30	41	174	3	17	34	242	2	22	3	336	1	42	19
81	7	4	25	128	4	28	34	175	3	16	26	244	2	20	23	338	1	41	42
82	6	59	14	129	4	26	29	176	3	15	19	246	2	19	44	340	1	41	6
83	6	54	11	130	4	24	26	177	3	14	13	248	2	18	37	342	1	40	31
84	6	49	16	131	4	22	25	178	3	13	8	250	2	17	30	344	1	39	56
85	6	44	26	132	4	20	26	179	3	12	3	252	2	16	25	346	1	39	6
86	6	39	44	133	4	18	28	180	3	10	59	254	2	15	20	348	1	38	47
87	6	35	8	134	4	16	33	181	3	9	56	256	2	14	17	350	1	38	13
88	6	30	39	135	4	14	39	182	3	8	53	258	2	13	15	352	1	37	39
89	6	26	16	136	4	12	46	183	3	7	51	260	2	12	13	354	1	37	6
90	6	21	59	137	4	10	56	184	3	6	50	262	2	11	12	356	1	36	34
91	6	17	46	138	4	9	6	185	3	5	49	264	2	10	13	358	1	36	1
92	6	13	40	139	4	7	16	186	3	4	49	266	2	9	14	360	1	35	29
93	6	9	39	140	4	5	33	187	3	3	50	268	2	8	16	362	1	34	58
94	6	5	43	141	4	3	48	188	3	2	51	270	2	7	19	364	1	34	26
95	6	1	52	142	4	2	5	189	3	1	53	272	2	6	23	366	1	33	55
96	5	58	6	143	4	0	24	190	3	0	56	274	2	5	28	368	1	33	25

TABLE XXXII.—(*continued*).

Angles subtended by a 10-ft. Rod at Distances from 50 to 1500 Feet.

Feet.	Angle.			Feet.	Angle.			Feet.	Angle.			Feet.	Angle.			Feet.	Angle.		
	°	′	″		°	′	″		°	′	″		°	′	″		°	′	″
370	1	32	54	495	1	9	27	666	0	51	37	942	0	36	30	1224	0	28	5
372	1	32	24	498	1	9	2	672	0	51	9	948	0	36	16	1230	0	27	57
374	1	31	55	501	1	8	37	678	0	50	42	954	0	36	2	1236	0	27	49
376	1	31	25	504	1	8	12	684	0	50	15	960	0	35	48	1242	0	27	41
378	1	30	56	507	1	7	48	690	0	49	49	966	0	35	35	1248	0	27	32
380	1	30	28	510	1	7	24	696	0	49	23	972	0	35	22	1254	0	27	25
382	1	29	59	513	1	7	1	702	0	48	56	978	0	35	9	1260	0	27	17
384	1	29	31	516	1	6	37	708	0	48	33	984	0	34	56	1266	0	27	9
386	1	29	3	519	1	6	14	714	0	48	9	990	0	34	43	1272	0	27	1
388	1	28	36	522	1	5	51	720	0	47	44	996	0	34	31	1278	0	26	54
390	1	28	9	525	1	5	29	726	0	47	21	1002	0	34	18	1284	0	26	46
392	1	27	41	528	1	5	6	732	0	46	57	1008	0	34	6	1290	0	26	39
394	1	27	18	531	1	4	45	738	0	46	35	1014	0	33	54	1296	0	26	31
396	1	26	48	534	1	4	22	744	0	46	12	1020	0	33	42	1302	0	26	24
398	1	26	24	537	1	4	1	750	0	45	50	1026	0	33	30	1308	0	26	17
400	1	25	56	540	1	3	39	756	0	45	28	1032	0	33	18	1314	0	26	10
402	1	25	31	543	1	3	19	762	0	45	7	1038	0	33	7	1320	0	26	2
405	1	24	53	546	1	2	58	768	0	44	46	1044	0	32	55	1326	0	25	55
408	1	24	15	549	1	2	37	774	0	44	25	1050	0	32	45	1332	0	25	48
411	1	23	38	552	1	2	16	780	0	44	4	1056	0	32	33	1338	0	25	41
414	1	23	2	555	1	1	56	786	0	43	44	1062	0	32	22	1344	0	25	34
417	1	22	26	558	1	1	36	792	0	43	24	1068	0	32	11	1350	0	25	28
420	1	21	51	561	1	1	17	798	0	43	5	1074	0	32	1	1356	0	25	21
423	1	21	16	564	1	0	57	804	0	42	45	1080	0	31	49	1362	0	25	14
426	1	20	42	567	1	0	38	810	0	42	26	1086	0	31	39	1368	0	25	7
429	1	20	8	570	1	0	19	816	0	42	7	1092	0	31	29	1374	0	25	1
432	1	19	35	573	1	0	0	822	0	41	49	1098	0	31	19	1380	0	24	54
435	1	19	2	576	0	59	41	828	0	41	31	1104	0	31	8	1386	0	24	48
438	1	18	29	579	0	59	22	834	0	41	13	1116	0	30	48	1398	0	24	35
441	1	17	57	581	0	59	4	840	0	40	55	1122	0	30	41	1404	0	24	28
444	1	17	26	585	0	58	46	846	0	40	38	1128	0	30	28	1410	0	24	22
447	1	16	54	588	0	58	27	852	0	40	21	1134	0	30	19	1416	0	24	16
450	1	16	24	591	0	58	10	858	0	40	4	1140	0	30	9	1422	0	24	10
453	1	15	53	594	0	57	52	864	0	39	47	1146	0	30	0	1428	0	24	4
456	1	15	23	597	0	57	35	870	0	39	31	1152	0	29	51	1434	0	23	58
459	1	14	54	600	0	57	17	876	0	39	14	1158	0	29	41	1440	0	23	52
462	1	14	24	606	0	56	44	882	0	38	58	1164	0	29	32	1446	0	23	46
465	1	13	56	612	0	56	10	888	0	38	43	1170	0	29	33	1452	0	23	40
468	1	13	27	618	0	55	38	894	0	38	27	1176	0	29	14	1458	0	23	35
471	1	12	59	624	0	55	5	900	0	38	12	1182	0	29	5	1464	0	23	28
474	1	12	32	630	0	54	34	906	0	37	56	1188	0	28	56	1470	0	23	23
477	1	12	24	636	0	54	3	912	0	37	41	1194	0	28	47	1476	0	23	17
480	1	11	37	642	0	53	33	918	0	37	27	1200	0	28	39	1482	0	23	12
483	1	11	10	648	0	53	3	924	0	37	12	1206	0	28	31	1488	0	23	6
486	1	10	44	654	0	52	34	930	0	36	58	1212	0	28	22	1494	0	23	0
489	1	10	18	660	0	52	5	936	0	36	43	1218	0	28	13	1500	0	22	55
492	1	9	52																

TABLE XXXIII.

Useful Constants and Numbers.

Ratio of circumference to diameter of a circle .. .. $= \pi = 3 \cdot 141592653590$.
Log $\pi = 0 \cdot 497149872694$.
$\pi^2 = 9 \cdot 869604401089$ .. .. $\sqrt{\pi} = 1 \cdot 772453850906$.
Arc of same length as radius .. .. $= 180^\circ \div \pi = 10800' \div \pi = 648000'' \div \pi$.
$180^\circ \div \pi = 57^\circ \cdot 2957795130$ .. .. log $= 1 \cdot 7581226324009$.
$10800' \div \pi = 3437' \cdot 7467707849$ .. .. log $= 3 \cdot 5362738827793$.
$648000'' \div \pi = 206264'' \cdot 8062470964$ .. .. log $= 5 \cdot 314425133176$.
Tropical year $=$ 365d. 5h. 48m. 47s.·588 $=$ 365d.·242217456 .. .. log $= 2 \cdot 5625810$.
Sidereal year $=$ 365d. 6h. 9m. 10s.·742 $=$ 365d.·256374332 .. .. log $= 2 \cdot 5625978$.
24h. sol. t. $=$ 24h. 3m. 56s.·555335 sid. t. $=$ 24h. $\times$ 1·00273791 .. log 1·002 $=$ 0·0011874.
24h. sid. t. $=$ 24h. $-$ (3m. 55s.·90944) sol. t. $=$ 24h. $\times$ 0·9972696 log 0·997 $=$ 9·9988126.
British Imperial gallon $=$ 277·274 cubic inches .. .. log $= 2 \cdot 4429091$.
10 lbs. of distilled water at 62° F. $=$ 1 gallon.
Length of sec. pend. in inches, at London, 39·13929; Paris, 39·1285; New York, 39·1285.
French mètre $=$ 3·2808992 English feet $=$ 39·3707904 inches.
1 cubic inch of water (bar. 30 inches Fahr. therm. 62°) $=$ 252·458 Troy grains.
Radius reduced to seconds $=$ 206264·8 .. .. log 5·3144251.
" " minutes $=$ 3437·74677 .. .. log 3·5362739.
" " degrees $=$ 57·295780 .. .. log 1·7581226.
No. of Sexagesimal degrees in a Centesimal degree $=$ 0·9 .. .. log $\bar{1} \cdot 9542425$.
No. of Sexagesimal minutes in a Centesimal minute $=$ 0·54 .. .. .. log $\bar{1} \cdot 7323938$.
No. of Sexagesimal seconds in a Centesimal second $=$ 0·324.. .. .. .. log $\bar{1} \cdot 5105450$.
No. of feet in a statute mile $=$5280 .. .. log 3·7226339.
No. of feet in a geographical mile $=$ 6075·6 .. .. log 3·7835892.
German square miles $\times$ by 21·9 $=$ English square miles.
English square miles $\div$ by 21·9 $=$ German square miles.
Russian square versts $\div$ by 2·2 $=$ English square miles.
English square miles $\times$ by 2·2 $=$ Russian square versts.
The square of the distance in statute miles $-$ $\frac{1}{7}$ of it $=$ correction for curvature and refraction, in feet.
Diurnal acceleration of stars ($=$ 3m. 55s.·9093) expressed in mean solar seconds $=$ 235·9093
log 2·3727441.
Sidereal day ($=$ 23h. 56m. 4s.·09) expressed in mean solar days $=$ 0·99726967 .. log $\bar{1} \cdot 9988127$.
Mean solar day ($=$ 24h. 3m. 56s.·5554) expressed in sidereal days $=$ 1·00273791 log 0·0011874.
No. of French mètres in a toise $=$ 1·949040 .. .. log 0·2898127.
No. of English yards in a French toise $=$ 2·1315308 .. .. log 0·3286916.
No. of English feet in a French toise $=$ 6·3945925 .. .. log 0·8058128.
1 Gunter's chain $=$ 66 feet.
80 Gunter's chains $=$ 1 statute mile.
Links $\times$ 22 $=$ yards.
Links $\times$ 66 $=$ feet.

To find the solidity of a cylinder, multiply the square of the diameter of its base by 0·7854, and the product multiplied by the perpendicular height of the cylinder will be its solidity.

TABLE XXXIV.

For Converting Metrical Weights and Measures.

Hectare.		Acre.	Kilomètre.		Eng. Mile.	Square. Kilomètre.		Square. Eng. Mile.
0·405	**1**	2·471	1·609	**1**	0·621	2·592	**1**	0·386
0·809	**2**	4·942	3·219	**2**	1·243	5·184	**2**	0·772
1·214	**3**	7·413	4·828	**3**	1·864	7·776	**3**	1·158
1·619	**4**	9·885	6·438	**4**	2·486	10·368	**4**	1·544
2·023	**5**	12·356	8·047	**5**	3·107	12·960	**5**	1·930
2·428	**6**	14·827	9·656	**6**	3·728	15·552	**6**	2·316
2·833	**7**	17·298	11·265	**7**	4·350	18·144	**7**	2·702
3·237	**8**	19·769	12·879	**8**	4·971	20·736	**8**	3·088
3·642	**9**	22·240	14·484	**9**	5·592	23·328	**9**	3·474
4·047	**10**	24·711	16·093	**10**	6·214	25·920	**10**	3·860
8·093	**20**	49·423	32·186	**20**	12·428	51·840	**20**	7·720
12·140	**30**	74·134	48·279	**30**	18·641	77·760	**30**	11·580
16·187	**40**	98·846	64·373	**40**	24·855	103·680	**40**	15·440
20·234	**50**	123·557	80·466	**50**	31·c69	129·600	**50**	19·300
24·286	**60**	148·268	96·559	**60**	37·283	155·520	**60**	23·160
28·327	**70**	172·980	112·652	**70**	43·497	181·440	**70**	27·020
32·373	**80**	197·692	128·746	**80**	49·710	207·360	**80**	30·880
36·420	**90**	222·903	144·839	**90**	55·924	233·280	**90**	34·740
40·467	**100**	247·114	160·932	**100**	62·138	259·200	**100**	38·601

Mètre.		Yard.	Kilo-gramme.		Lb. Avoir.	Litre.		Gallons.
0·914	**1**	1·094	0·454	**1**	2·20	4·54	**1**	0·22
1·829	**2**	2·187	0·907	**2**	4·41	9·09	**2**	0·44
2·743	**3**	3·281	1·361	**3**	6·61	13·63	**3**	0·66
3·658	**4**	4·374	1·814	**4**	8·82	18·17	**4**	0·88
4·572	**5**	5·468	2·268	**5**	11·02	22·72	**5**	1·10
5·486	**6**	6·562	2·722	**6**	13·23	27·26	**6**	1·32
6·401	**7**	7·655	3·175	**7**	15·43	31·80	**7**	1·54
7·315	**8**	8·749	3·629	**8**	17·64	36·35	**8**	1·76
8·229	**9**	9·843	4·082	**9**	19·84	40·89	**9**	1·98
9·144	**10**	10·936	4·536	**10**	22·05	45·43	**10**	2·20
18·288	**20**	21·873	9·072	**20**	44·09	90·87	**20**	4·40
27·432	**30**	32·809	13·608	**30**	66·14	136·30	**30**	6·60
36·576	**40**	43·745	18·144	**40**	88·18	181·74	**40**	8·80
45·719	**50**	54·682	22·679	**50**	110·23	227·17	**50**	11·00
54·863	**60**	65·618	27·215	**60**	132·28	272·61	**60**	13·20
64·007	**70**	76·554	31·752	**70**	154·32	318·04	**70**	15·40
73·151	**80**	87·491	36·288	**80**	176·37	363·48	**80**	17·60
82·295	**90**	98·427	40·823	**90**	198·42	408·91	**90**	19·80
91·438	**100**	109·363	45·359	**100**	220·46	454·35	**100**	22·01

For the use of these tables the following explanation is necessary:—The figures in heavier type represent either of the columns beside it, as the case may be; viz., with hectares and acres in the first set of columns, 1 acre = 0·405 hectare, and vice versâ, 1 hectare = 2·471 acres, and so on.

TABLE XXXV.

LOGARITHMS OF NUMBERS

No. 1 to 100 **Log. 0·000000 to 2·000000**

No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0·000000	21	1·322219	41	1·612784	61	1·785330	81	1·908485
2	0·301030	22	1·342423	42	1·623249	62	1·792392	82	1·913814
3	0·477121	23	1·361728	43	1·633468	63	1·799341	83	1·919078
4	0·602060	24	1·380211	44	1·643453	64	1·806180	84	1·924279
5	0·698970	25	1·397940	45	1·653213	65	1·812913	85	1·929419
6	0·778151	26	1·414973	46	1·662758	66	1·819544	86	1·934498
7	0·845098	27	1·431364	47	1·672098	67	1·826075	87	1·939519
8	0·903090	28	1·447158	48	1·681241	68	1·832509	88	1·944483
9	0·954243	29	1·462398	49	1·690196	69	1·838849	89	1·949390
10	1·000000	30	1·477121	50	1·698970	70	1·845098	90	1·954243
11	1·041393	31	1·491362	51	1·707570	71	1·851258	91	1·959041
12	1·079181	32	1·505150	52	1·716003	72	1·857332	92	1·963788
13	1·113943	33	1·518514	53	1·724276	73	1·863323	93	1·968483
14	1·146128	34	1·531479	54	1·732394	74	1·869232	94	1·973128
15	1·176091	35	1·544068	55	1·740363	75	1·875061	95	1·977724
16	1·204120	36	1·556303	56	1·748188	76	1·880814	96	1·982271
17	1·230449	37	1·568202	57	1·755875	77	1·886491	97	1·986772
18	1·255273	38	1·579784	58	1·763428	78	1·892095	98	1·991226
19	1·278754	39	1·591065	59	1·770852	79	1·897627	99	1·995635
20	1·301030	40	1·602060	60	1·778151	80	1·903090	100	2·000000

No. 1000 to 1149 **Log. 0 to 060320**

No.	0	1	2	3	4	5	6	7	8	9	D.
100	000000	000434	000868	001301	001734	002166	002598	003029	003461	003891	432
101	004321	004751	005181	005609	006038	006466	006894	007321	007748	008174	428
102	008600	009026	009451	009876	010300	010724	011147	011570	011993	012415	424
103	012837	013259	013680	014100	014521	014940	015360	015779	016197	016616	420
104	017033	017451	017868	018284	018700	019116	019532	019947	020361	020775	416
105	021189	021603	022016	022428	022841	023252	023664	024075	024486	024896	412
106	025306	025715	026125	026533	026942	027350	027757	028164	028571	028978	408
107	029384	029789	030195	030600	031004	031408	031812	032216	032619	033021	404
108	033424	033826	034227	034628	035029	035430	035830	036230	036629	037028	400
109	037426	037825	038223	038620	039017	039414	039811	040207	040602	040998	397
110	041393	041787	042182	042576	042969	043362	043755	044148	044540	044932	393
111	045323	045714	046105	046495	046885	047275	047664	048053	048442	048830	389
112	049218	049606	049993	050380	050766	051153	051538	051924	052309	052694	386
113	053078	053463	053846	054230	054613	054996	055378	055760	056142	056524	383
114	056905	057286	057666	058046	058426	058805	059185	059563	059942	060320	379
No.	0	1	2	3	4	5	6	7	8	9	D

D.	1	2	3	4	5	6	7	8	9
378	38	76	113	151	189	227	265	302	340
380	38	76	114	152	190	228	266	304	342
382	38	76	115	153	191	229	267	306	344
384	38	77	115	154	192	230	269	307	346
386	39	77	116	154	193	232	270	309	347
388	39	78	116	155	194	233	272	310	349
390	39	78	117	156	195	234	273	312	351
392	39	78	118	157	196	235	274	314	353
394	39	79	118	158	197	236	276	315	355
396	40	79	119	158	198	238	277	317	356
398	40	80	119	159	199	239	279	318	358
400	40	80	120	160	200	240	280	320	360
402	40	80	121	161	201	241	281	322	362
404	40	81	121	162	202	242	283	323	364
406	41	81	122	162	203	244	284	325	365

D.	1	2	3	4	5	6	7	8	9
408	41	82	122	163	204	245	286	326	367
410	41	82	123	164	205	246	287	328	369
412	41	82	124	165	206	247	288	330	371
414	41	83	124	166	207	248	290	331	373
416	42	83	125	166	208	250	291	333	374
418	42	84	125	167	209	251	293	334	376
420	42	84	126	168	210	252	294	336	378
422	42	84	127	169	211	253	295	338	380
424	42	85	127	170	212	254	297	339	382
426	43	85	128	170	213	256	298	341	383
428	43	86	128	171	214	257	300	342	385
430	43	86	129	172	215	258	301	344	387
432	43	86	130	173	216	259	302	346	389
434	43	87	130	174	217	260	304	347	391

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 1150 to 1499 — Log. 060698 to 175802

No.	0	1	2	3	4	5	6	7	8	9	D.
115	060698	061075	061452	061829	062206	062582	062958	063333	063709	064083	376
116	064458	064832	065206	065580	065953	066326	066699	067071	067443	067815	373
117	068186	068557	068927	069298	069668	070038	070407	070776	071145	071514	370
118	071882	072250	072617	072985	073352	073718	074085	074451	074816	075182	366
119	075547	075912	076276	076640	077004	077368	077731	078094	078457	078819	363
120	079181	079543	079904	080266	080626	080987	081347	081707	082067	082426	360
121	082785	083144	083503	083861	084219	084576	084934	085291	085647	086004	357
122	086360	086716	087071	087426	087781	088136	088490	088845	089198	089552	355
123	089905	090258	090611	090963	091315	091667	092018	092370	092721	093071	352
124	093422	093772	094122	094471	094820	095169	095518	095866	096215	096562	349
125	096910	097257	097604	097951	098298	098644	098990	099335	099681	100026	346
126	100371	100715	101059	101403	101747	102091	102434	102777	103119	103462	343
127	103804	104146	104487	104828	105169	105510	105851	106191	106531	106871	341
128	107210	107549	107888	108227	108565	108903	109241	109579	109916	110253	338
129	110590	110926	111263	111599	111934	112270	112605	112940	113275	113609	335
130	113943	114277	114611	114944	115278	115611	115943	116276	116608	116940	333
131	117271	117603	117934	118265	118595	118926	119256	119586	119915	120245	330
132	120574	120903	121231	121560	121888	122216	122544	122871	123198	123525	328
133	123852	124178	124504	124830	125156	125481	125806	126131	126456	126781	325
134	127105	127429	127753	128076	128399	128722	129045	129368	129690	130012	323
135	130334	130655	130977	131298	131619	131939	132260	132580	132900	133219	321
136	133539	133858	134177	134496	134814	135133	135451	135769	136086	136403	318
137	136721	137037	137354	137671	137987	138303	138618	138934	139249	139564	316
138	139879	140194	140508	140822	141136	141450	141763	142076	142389	142702	314
139	143015	143327	143639	143951	144263	144574	144885	145196	145507	145818	311
140	146128	146438	146748	147058	147367	147676	147985	148294	148603	148911	309
141	149219	149527	149835	150142	150449	150756	151063	151370	151676	151982	307
142	152288	152594	152900	153205	153510	153815	154120	154424	154728	155032	305
143	155336	155640	155943	156246	156549	156852	157154	157457	157759	158061	303
144	158362	158664	158965	159266	159567	159868	160168	160469	160769	161068	301
145	161368	161667	161967	162266	162564	162863	163161	163460	163758	164055	299
146	164353	164650	164947	165244	165541	165838	166134	166430	166726	167022	297
147	167317	167613	167908	168203	168497	168792	169086	169380	169674	169968	295
148	170262	170555	170848	171141	171434	171726	172019	172311	172603	172895	293
149	173186	173478	173769	174060	174351	174641	174932	175222	175512	175802	291
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9	D.	1	2	3	4	5	6	7	8	9
290	29	58	87	116	145	174	203	232	261	334	33	67	100	134	167	200	234	267	301
292	29	58	88	117	146	175	204	234	263	336	34	67	101	134	168	202	235	269	302
294	29	59	88	118	147	176	206	235	265	338	34	68	101	135	169	203	237	270	304
296	30	59	89	118	148	178	207	237	266	340	34	68	102	136	170	204	238	272	306
298	30	60	89	119	149	179	209	238	268	342	34	68	103	137	171	205	239	274	308
300	30	60	90	120	150	180	210	240	270	344	34	69	103	138	172	206	241	275	310
302	30	60	91	121	151	181	211	242	272	346	35	69	104	138	173	208	242	277	311
304	30	61	91	122	152	182	213	243	274	348	35	70	104	139	174	209	244	278	313
306	31	61	92	122	153	184	214	245	275	350	35	70	105	140	175	210	245	280	315
308	31	62	92	123	154	185	216	246	277	352	35	70	106	141	176	211	246	282	317
310	31	62	93	124	155	186	217	248	279	354	35	71	106	142	177	212	248	283	319
312	31	62	94	125	156	187	218	250	281	356	36	71	107	142	178	214	249	285	320
314	31	63	94	126	157	188	220	251	283	358	36	72	107	143	179	215	251	286	322
316	32	63	95	126	158	190	221	253	284	360	36	72	108	144	180	216	252	288	324
318	32	64	95	127	159	191	223	254	286	362	36	72	109	145	181	217	253	290	326
320	32	64	96	128	160	192	224	256	288	364	36	73	109	146	182	218	255	291	328
322	32	64	97	129	161	193	225	258	290	366	37	73	110	146	183	220	256	293	329
324	32	65	97	130	162	194	227	259	292	368	37	74	110	147	184	221	258	294	331
326	33	65	98	130	163	196	228	261	293	370	37	74	111	148	185	222	259	296	333
328	33	66	98	131	164	197	230	262	295	372	37	74	112	149	186	223	260	298	335
330	33	66	99	132	165	198	231	264	297	374	37	75	112	150	187	224	262	299	337
332	33	66	100	133	166	199	232	266	299	376	38	75	113	150	188	226	263	301	338

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 1500 to 1899 **Log. 176091 to 278525**

No.	0	1	2	3	4	5	6	7	8	9	D.
150	176091	176381	176670	176959	177248	177536	177825	178113	178401	178689	289
151	178977	179264	179552	179839	180126	180413	180699	180986	181272	181558	287
152	181844	182129	182415	182700	182985	183270	183555	183839	184123	184407	285
153	184691	184975	185259	185542	185825	186108	186391	186674	186956	187239	283
154	187521	187803	188084	188366	188647	188928	189209	189490	189771	190051	281
155	190332	190612	190892	191171	191451	191730	192010	192289	192567	192846	279
156	193125	193403	193681	193959	194237	194514	194792	195069	195346	195623	278
157	195900	196176	196453	196729	197005	197281	197556	197832	198107	198382	276
158	198657	198932	199206	199481	199755	200029	200303	200577	200850	201124	274
159	201397	201670	201943	202216	202488	202761	203033	203305	203577	203848	272
160	204120	204391	204663	204934	205204	205475	205746	206016	206286	206556	271
161	206826	207096	207365	207634	207904	208173	208441	208710	208979	209247	269
162	209515	209783	210051	210319	210586	210853	211121	211388	211654	211921	267
163	212188	212454	212720	212986	213252	213518	213783	214049	214314	214579	266
164	214844	215109	215373	215638	215902	216166	216430	216694	216957	217221	264
165	217484	217747	218010	218273	218536	218798	219060	219323	219585	219846	262
166	220108	220370	220631	220892	221153	221414	221675	221936	222196	222456	261
167	222716	222976	223236	223496	223755	224015	224274	224533	224792	225051	259
168	225309	225568	225826	226084	226342	226600	226858	227115	227372	227630	258
169	227887	228144	228400	228657	228913	229170	229426	229682	229938	230193	256
170	230449	230704	230960	231215	231470	231724	231979	232234	232488	232742	255
171	232996	233250	233504	233757	234011	234264	234517	234770	235023	235276	253
172	235528	235781	236033	236285	236537	236789	237041	237292	237544	237795	252
173	238046	238297	238548	238799	239049	239299	239550	239800	240050	240300	250
174	240549	240799	241048	241297	241546	241795	242044	242293	242541	242790	249
175	243038	243286	243534	243782	244030	244277	244525	244772	245019	245266	248
176	245513	245759	246006	246252	246499	246745	246991	247237	247482	247728	246
177	247973	248219	248464	248709	248954	249198	249443	249687	249932	250176	245
178	250420	250664	250908	251151	251395	251638	251881	252125	252368	252610	243
179	252853	253096	253338	253580	253822	254064	254306	254548	254790	255031	242
180	255273	255514	255755	255996	256237	256477	256718	256958	257198	257439	241
181	257679	257918	258158	258398	258637	258877	259116	259355	259594	259833	239
182	260071	260310	260548	260787	261025	261263	261501	261739	261976	262214	238
183	262451	262688	262925	263162	263399	263636	263873	264109	264346	264582	237
184	264818	265054	265290	265525	265761	265996	266232	266467	266702	266937	235
185	267172	267406	267641	267875	268110	268344	268578	268812	269046	269279	234
186	269513	269746	269980	270213	270446	270679	270912	271144	271377	271609	233
187	271842	272074	272306	272538	272770	273001	273233	273464	273696	273927	232
188	274158	274389	274620	274850	275081	275311	275542	275772	276002	276232	230
189	276462	276692	276921	277151	277380	277609	277838	278067	278296	278525	229
No	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9	D.	1	2	3	4	5	6	7	8	9
228	23	46	68	91	114	137	160	182	205	260	26	52	78	104	130	156	182	208	234
230	23	46	69	92	115	138	161	184	207	262	26	52	79	105	131	157	183	210	236
232	23	46	70	93	116	139	162	186	209	264	26	53	79	106	132	158	185	211	238
234	23	47	70	94	117	140	164	187	211	266	27	53	80	106	133	160	186	213	239
236	24	47	71	94	118	142	165	189	212	268	27	54	80	107	134	161	188	214	241
238	24	48	71	95	119	143	167	190	214	270	27	54	81	108	135	162	189	216	243
240	24	48	72	96	120	144	168	192	216	272	27	54	82	109	136	163	190	218	245
242	24	48	73	97	121	145	169	194	218	274	27	55	82	110	137	164	192	219	247
244	24	49	73	98	122	146	171	195	220	276	28	55	83	110	138	166	193	221	248
246	25	49	74	98	123	148	172	197	221	278	28	56	83	111	139	167	195	222	250
248	25	50	74	99	124	149	174	198	223	280	28	56	84	112	140	168	196	224	252
250	25	50	75	100	125	150	175	200	225	282	28	56	85	113	141	169	197	226	254
252	25	50	76	101	126	151	176	202	227	284	28	57	85	114	142	170	199	227	256
254	25	51	76	102	127	152	178	203	229	286	29	57	86	114	143	172	200	229	257
256	26	51	77	102	128	154	179	205	230	288	29	58	86	115	144	173	202	230	259
258	26	52	77	103	129	155	181	206	232	290	29	58	87	116	145	174	203	232	261

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS.

No. 1900 to 2349 — Log. 278754 to 370883

No.	0	1	2	3	4	5	6	7	8	9	D.
190	278754	278982	279211	279439	279667	279895	280123	280351	280578	280806	228
191	281033	281261	281488	281715	281942	282169	282396	282622	282849	283075	227
192	283301	283527	283753	283979	284205	284431	284656	284882	285107	285332	226
193	285557	285782	286007	286232	286456	286681	286905	287130	287354	287578	225
194	287802	288026	288249	288473	288696	288920	289143	289366	289589	289812	223
195	290035	290257	290480	290702	290925	291147	291369	291591	291813	292034	222
196	292256	292478	292699	292920	293141	293363	293584	293804	294025	294246	221
197	294466	294687	294907	295127	295347	295567	295787	296007	296226	296446	220
198	296665	296884	297104	297323	297542	297761	297979	298198	298416	298635	219
199	298853	299071	299289	299507	299725	299943	300161	300378	300595	300813	218
200	301030	301247	301464	301681	301898	302114	302331	302547	302764	302980	217
201	303196	303412	303628	303844	304059	304275	304491	304706	304921	305136	216
202	305351	305566	305781	305996	306211	306425	306639	306854	307068	307282	215
203	307496	307710	307924	308137	308351	308564	308778	308991	309204	309417	213
204	309630	309843	310056	310268	310481	310693	310906	311118	311330	311542	212
205	311754	311966	312177	312389	312600	312812	313023	313234	313445	313656	211
206	313867	314078	314289	314499	314710	314920	315130	315340	315551	315760	210
207	315970	316180	316390	316599	316809	317018	317227	317436	317646	317854	209
208	318063	318272	318481	318689	318898	319106	319314	319522	319730	319938	208
209	320146	320354	320562	320769	320977	321184	321391	321598	321805	322012	207
210	322219	322426	322633	322839	323046	323252	323458	323665	323871	324077	206
211	324282	324488	324694	324899	325105	325310	325516	325721	325926	326131	205
212	326336	326541	326745	326950	327155	327359	327563	327767	327972	328176	204
213	328380	328583	328787	328991	329194	329398	329601	329805	330008	330211	203
214	330414	330617	330819	331022	331225	331427	331630	331832	332034	332236	202
215	332438	332640	332842	333044	333246	333447	333649	333850	334051	334253	202
216	334454	334655	334856	335057	335257	335458	335658	335859	336059	336260	201
217	336460	336660	336860	337060	337260	337459	337659	337858	338058	338257	200
218	338456	338656	338855	339054	339253	339451	339650	339849	340047	340246	199
219	340444	340642	340841	341039	341237	341435	341632	341830	342028	342225	198
220	342423	342620	342817	343014	343212	343409	343606	343802	343999	344196	197
221	344392	344589	344785	344981	345178	345374	345570	345766	345962	346157	196
222	346353	346549	346744	346939	347135	347330	347525	347720	347915	348110	195
223	348305	348500	348694	348889	349083	349278	349472	349666	349860	350054	194
224	350248	350442	350636	350829	351023	351216	351410	351603	351796	351989	193
225	352183	352375	352568	352761	352954	353147	353339	353532	353724	353916	193
226	354108	354301	354493	354685	354876	355068	355260	355452	355643	355834	192
227	356026	356217	356408	356599	356790	356981	357172	357363	357554	357744	191
228	357935	358125	358316	358506	358696	358886	359076	359266	359456	359646	190
229	359835	360025	360215	360404	360593	360783	360972	361161	361350	361539	189
230	361728	361917	362105	362294	362482	362671	362859	363048	363236	363424	188
231	363612	363800	363988	364176	364363	364551	364739	364926	365113	365301	188
232	365488	365675	365862	366049	366236	366423	366610	366796	366983	367169	187
233	367356	367542	367729	367915	368101	368287	368473	368659	368845	369030	186
234	369216	369401	369587	369772	369958	370143	370328	370513	370698	370883	185
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9
184	18	37	55	74	92	110	129	147	166
186	19	37	56	74	93	112	130	149	167
188	19	38	56	75	94	113	132	150	169
190	19	38	57	76	95	114	133	152	171
192	19	38	58	77	96	115	134	154	173
194	19	39	58	78	97	116	136	155	175
196	20	39	59	78	98	118	137	157	176
198	20	40	59	79	99	119	139	158	178
200	20	40	60	80	100	120	140	160	180
202	20	40	61	81	101	121	141	162	182
204	20	41	61	82	102	122	143	163	184
206	21	41	62	82	103	124	144	165	185

D.	1	2	3	4	5	6	7	8	9
208	21	42	62	83	104	125	146	166	187
210	21	42	63	84	105	126	147	168	189
212	21	42	64	85	106	127	148	170	191
214	21	43	64	86	107	128	150	171	193
216	22	43	65	86	108	130	151	173	194
218	22	44	65	87	109	131	153	174	196
220	22	44	66	88	110	132	154	176	198
222	22	44	67	89	111	133	155	178	200
224	22	45	67	90	112	134	157	179	202
226	23	45	68	90	113	136	158	181	203
228	23	46	68	91	114	137	160	182	205

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 2350 to 2849 **Log. 371068 to 454692**

No.	0	1	2	3	4	5	6	7	8	9	D.
235	371068	371253	371437	371622	371806	371991	372175	372360	372544	372728	184
236	372912	373096	373280	373464	373647	373831	374015	374198	374382	374565	184
237	374748	374932	375115	375298	375481	375664	375846	376029	376212	376394	183
238	376577	376759	376942	377124	377306	377488	377670	377852	378034	378216	182
239	378398	378580	378761	378943	379124	379306	379487	379668	379849	380030	181
240	380211	380392	380573	380754	380934	381115	381296	381476	381656	381837	181
241	382017	382197	382377	382557	382737	382917	383097	383277	383456	383636	180
242	383815	383995	384174	384353	384533	384712	384891	385070	385249	385428	179
243	385606	385785	385964	386142	386321	386499	386677	386856	387034	387212	178
244	387390	387568	387746	387923	388101	388279	388456	388634	388811	388989	178
245	389166	389343	389520	389698	389875	390051	390228	390405	390582	390759	177
246	390935	391112	391288	391464	391641	391817	391993	392169	392345	392521	176
247	392697	392873	393048	393224	393400	393575	393751	393926	394101	394277	176
248	394452	394627	394802	394977	395152	395326	395501	395676	395850	396025	175
249	396199	396374	396548	396722	396896	397071	397245	397419	397592	397766	174
250	397940	398114	398287	398461	398634	398808	398981	399154	399328	399501	173
251	399674	399847	400020	400192	400365	400538	400711	400883	401056	401228	173
252	401401	401573	401745	401917	402089	402261	402433	402605	402777	402949	172
253	403121	403292	403464	403635	403807	403978	404149	404320	404492	404663	171
254	404834	405005	405176	405346	405517	405688	405858	406029	406199	406370	171
255	406540	406710	406881	407051	407221	407391	407561	407731	407901	408070	170
256	408240	408410	408579	408749	408918	409087	409257	409426	409595	409764	169
257	409933	410102	410271	410440	410609	410777	410946	411114	411283	411451	169
258	411620	411788	411956	412124	412293	412461	412629	412796	412964	413132	168
259	413300	413467	413635	413803	413970	414137	414305	414472	414639	414806	167
260	414973	415140	415307	415474	415641	415808	415974	416141	416308	416474	167
261	416641	416807	416973	417139	417306	417472	417638	417804	417970	418135	166
262	418301	418467	418633	418798	418964	419129	419295	419460	419625	419791	165
263	419956	420121	420286	420451	420616	420781	420945	421110	421275	421439	165
264	421604	421768	421933	422097	422261	422426	422590	422754	422918	423082	164
265	423246	423410	423574	423737	423901	424065	424228	424392	424555	424718	164
266	424882	425045	425208	425371	425534	425697	425860	426023	426186	426349	163
267	426511	426674	426836	426999	427161	427324	427486	427648	427811	427973	162
268	428135	428297	428459	428621	428783	428944	429106	429268	429429	429591	162
269	429752	429914	430075	430236	430398	430559	430720	430881	431042	431203	161
270	431364	431525	431685	431846	432007	432167	432328	432488	432649	432809	161
271	432969	433130	433290	433450	433610	433770	433930	434090	434249	434409	160
272	434569	434729	434888	435048	435207	435367	435526	435685	435844	436004	159
273	436163	436322	436481	436640	436799	436957	437116	437275	437433	437592	159
274	437751	437909	438067	438226	438384	438542	438701	438859	439017	439175	158
275	439333	439491	439648	439806	439964	440122	440279	440437	440594	440752	158
276	440909	441066	441224	441381	441538	441695	441852	442009	442166	442323	157
277	442480	442637	442793	442950	443106	443263	443419	443576	443732	443889	157
278	444045	444201	444357	444513	444669	444825	444981	445137	445293	445449	156
279	445604	445760	445915	446071	446226	446382	446537	446692	446848	447003	155
280	447158	447313	447468	447623	447778	447933	448088	448242	448397	448552	155
281	448706	448861	449015	449170	449324	449478	449633	449787	449941	450095	154
282	450249	450403	450557	450711	450865	451018	451172	451326	451479	451633	154
283	451786	451940	452093	452247	452400	452553	452706	452859	453012	453165	153
284	453318	453471	453624	453777	453930	454082	454235	454387	454540	454692	153
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9
152	15	30	46	61	76	91	106	122	137
154	15	31	46	62	77	92	108	123	139
156	16	31	47	62	78	94	109	125	140
158	16	32	47	63	79	95	111	126	142
160	16	32	48	64	80	96	112	128	144
162	16	32	49	65	81	97	113	130	146
164	16	33	49	66	82	98	115	131	148
166	17	33	50	66	83	100	116	133	149
168	17	34	50	67	84	101	118	134	151

D.	1	2	3	4	5	6	7	8	9
170	17	34	51	68	85	102	119	136	153
172	17	34	52	69	86	103	120	138	155
174	17	35	52	70	87	104	122	139	157
176	18	35	53	70	88	106	123	141	158
178	18	36	53	71	89	107	125	142	160
180	18	36	54	72	90	108	126	144	162
182	18	36	55	73	91	109	127	146	164
184	18	37	55	74	92	110	129	147	166

TABLE XXXV.—(*continued*)

LOGARITHMS OF NUMBERS

No. 2850 to 3349 **Log. 454845 to 524915**

No.	0	1	2	3	4	5	6	7	8	9	D.
285	454845	454997	455150	455302	455454	455606	455758	455910	456062	456214	152
286	456366	456518	456670	456821	456973	457125	457276	457428	457579	457731	152
287	457882	458033	458184	458336	458487	458638	458789	458940	459091	459242	151
288	459392	459543	459694	459845	459995	460146	460296	460447	460597	460748	151
289	460898	461048	461198	461348	461499	461649	461799	461948	462098	462248	150
290	462398	462548	462697	462847	462997	463146	463296	463445	463594	463744	150
291	463893	464042	464191	464340	464490	464639	464788	464936	465085	465234	149
292	465383	465532	465680	465829	465977	466126	466274	466423	466571	466719	149
293	466868	467016	467164	467312	467460	467608	467756	467904	468052	468200	148
294	468347	468495	468643	468790	468938	469085	469233	469380	469527	469675	148
295	469822	469969	470116	470263	470410	470557	470704	470851	470998	471145	147
296	471292	471438	471585	471732	471878	472025	472171	472318	472464	472610	146
297	472756	472903	473049	473195	473341	473487	473633	473779	473925	474071	146
298	474216	474362	474508	474653	474799	474944	475090	475235	475381	475526	146
299	475671	475816	475962	476107	476252	476397	476542	476687	476832	476976	145
300	477121	477266	477411	477555	477700	477844	477989	478133	478278	478422	145
301	478566	478711	478855	478999	479143	479287	479431	479575	479719	479863	144
302	480007	480151	480294	480438	480582	480725	480869	481012	481156	481299	144
303	481443	481586	481729	481872	482016	482159	482302	482445	482588	482731	143
304	482874	483016	483159	483302	483445	483587	483730	483872	484015	484157	143
305	484300	484442	484585	484727	484869	485011	485153	485295	485437	485579	142
306	485721	485863	486005	486147	486289	486430	486572	486714	486855	486997	142
307	487138	487280	487421	487563	487704	487845	487986	488127	488269	488410	141
308	488551	488692	488833	488974	489114	489255	489396	489537	489677	489818	141
309	489958	490099	490239	490380	490520	490661	490801	490941	491081	491222	140
310	491362	491502	491642	491782	491922	492062	492201	492341	492481	492621	140
311	492760	492900	493040	493179	493319	493458	493597	493737	493876	494015	139
312	494155	494294	494433	494572	494711	494850	494989	495128	495267	495406	139
313	495544	495683	495822	495960	496099	496238	496376	496515	496653	496791	139
314	496930	497068	497206	497344	497483	497621	497759	497897	498035	498173	138
315	498311	498448	498586	498724	498862	498999	499137	499275	499412	499550	138
316	499687	499824	499962	500099	500236	500374	500511	500648	500785	500922	137
317	501059	501196	501333	501470	501607	501744	501880	502017	502154	502291	137
318	502427	502564	502700	502837	502973	503109	503246	503382	503518	503655	136
319	503791	503927	504063	504199	504335	504471	504607	504743	504878	505014	136
320	505150	505286	505421	505557	505693	505828	505964	506099	506234	506370	136
321	506505	506640	506776	506911	507046	507181	507316	507451	507586	507721	135
322	507856	507991	508126	508260	508395	508530	508664	508799	508934	509068	135
323	509203	509337	509471	509606	509740	509874	510009	510143	510277	510411	134
324	510545	510679	510813	510947	511081	511215	511349	511482	511616	511750	134
325	511883	512017	512151	512284	512418	512551	512684	512818	512951	513084	133
326	513218	513351	513484	513617	513750	513883	514016	514149	514282	514415	133
327	514548	514681	514813	514946	515079	515211	515344	515476	515609	515741	133
328	515874	516006	516139	516271	516403	516535	516668	516800	516932	517064	132
329	517196	517328	517460	517592	517724	517855	517987	518119	518251	518382	132
330	518514	518646	518777	518909	519040	519171	519303	519434	519566	519697	131
331	519828	519959	520090	520221	520353	520484	520615	520745	520876	521007	131
332	521138	521269	521400	521530	521661	521792	521922	522053	522183	522314	131
333	522444	522575	522705	522835	522966	523096	523226	523356	523486	523616	130
334	523746	523876	524006	524136	524266	524396	524526	524656	524785	524915	130
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9	D.	1	2	3	4	5	6	7	8	9
130	13	26	39	52	65	78	91	104	117	142	14	28	43	57	71	85	99	114	128
132	13	26	40	53	66	79	92	106	119	144	14	29	43	58	72	86	101	115	130
134	13	27	40	54	67	80	94	107	121	146	15	29	44	58	73	88	102	117	131
136	14	27	41	54	68	82	95	109	122	148	15	30	44	59	74	89	104	118	133
138	14	28	41	55	69	83	97	110	124	150	15	30	45	60	75	90	105	120	135
140	14	28	42	56	70	84	98	112	126	152	15	30	46	61	76	91	106	122	137

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 3350 to 3899 **Log. 525045 to 590953**

No.	0	1	2	3	4	5	6	7	8	9	D.
335	525045	525174	525304	525434	525563	525693	525822	525951	526081	526210	129
336	526339	526469	526598	526727	526856	526985	527114	527243	527372	527501	129
337	527630	527759	527888	528016	528145	528274	528402	528531	528660	528788	129
338	528917	529045	529174	529302	529430	529559	529687	529815	529943	530072	128
339	530200	530328	530456	530584	530712	530840	530968	531096	531223	531351	128
340	531479	531607	531734	531862	531990	532117	532245	532372	532500	532627	128
341	532754	532882	533009	533136	533264	533391	533518	533645	533772	533899	127
342	534026	534153	534280	534407	534534	534661	534787	534914	535041	535167	127
343	535294	535421	535547	535674	535800	535927	536053	536180	536306	536432	126
344	536558	536685	536811	536937	537063	537189	537315	537441	537567	537693	126
345	537819	537945	538071	538197	538322	538448	538574	538699	538825	538951	126
346	539076	539202	539327	539452	539578	539703	539829	539954	540079	540204	125
347	540329	540455	540580	540705	540830	540955	541080	541205	541330	541454	125
348	541579	541704	541829	541953	542078	542203	542327	542452	542576	542701	125
349	542825	542950	543074	543199	543323	543447	543571	543696	543820	543944	124
350	544068	544192	544316	544440	544564	544688	544812	544936	545060	545183	124
351	545307	545431	545555	545678	545802	545925	546049	546172	546296	546419	124
352	546543	546666	546789	546913	547036	547159	547282	547405	547529	547652	123
353	547775	547898	548021	548144	548267	548389	548512	548635	548758	548881	123
354	549003	549126	549249	549371	549494	549616	549739	549861	549984	550106	123
355	550228	550351	550473	550595	550717	550840	550962	551084	551206	551328	122
356	551450	551572	551694	551816	551938	552060	552181	552303	552425	552547	122
357	552668	552790	552911	553033	553155	553276	553398	553519	553640	553762	121
358	553883	554004	554126	554247	554368	554489	554610	554731	554852	554973	121
359	555094	555215	555336	555457	555578	555699	555820	555940	556061	556182	121
360	556303	556423	556544	556664	556785	556905	557026	557146	557267	557387	120
361	557507	557627	557748	557868	557988	558108	558228	558349	558469	558589	120
362	558709	558829	558948	559068	559188	559308	559428	559548	559667	559787	120
363	559907	560026	560146	560265	560385	560504	560624	560743	560863	560982	119
364	561101	561221	561340	561459	561578	561698	561817	561936	562055	562174	119
365	562293	562412	562531	562650	562769	562887	563006	563125	563244	563362	119
366	563481	563600	563718	563837	563955	564074	564192	564311	564429	564548	119
367	564666	564784	564903	565021	565139	565257	565376	565494	565612	565730	118
368	565848	565966	566084	566202	566320	566437	566555	566673	566791	566909	118
369	567026	567144	567262	567379	567497	567614	567732	567849	567967	568084	118
370	568202	568319	568436	568554	568671	568788	568905	569023	569140	569257	117
371	569374	569491	569608	569725	569842	569959	570076	570193	570309	570426	117
372	570543	570660	570776	570893	571010	571126	571243	571359	571476	571592	117
373	571709	571825	571942	572058	572174	572291	572407	572523	572639	572755	116
374	572872	572988	573104	573220	573336	573452	573568	573684	573800	573915	116
375	574031	574147	574263	574379	574494	574610	574726	574841	574957	575072	116
376	575188	575303	575419	575534	575650	575765	575880	575996	576111	576226	115
377	576341	576457	576572	576687	576802	576917	577032	577147	577262	577377	115
378	577492	577607	577722	577836	577951	578066	578181	578295	578410	578525	115
379	578639	578754	578868	578983	579097	579212	579326	579441	579555	579669	114
380	579784	579898	580012	580126	580241	580355	580469	580583	580697	580811	114
381	580925	581039	581153	581267	581381	581495	581608	581722	581836	581950	114
382	582063	582177	582291	582404	582518	582631	582745	582858	582972	583085	114
383	583199	583312	583426	583539	583652	583765	583879	583992	584105	584218	113
384	584331	584444	584557	584670	584783	584896	585009	585122	585235	585348	113
385	585461	585574	585686	585799	585912	586024	586137	586250	586362	586475	113
386	586587	586700	586812	586925	587037	587149	587262	587374	587486	587599	112
387	587711	587823	587935	588047	588160	588272	588384	588496	588608	588720	112
388	588832	588944	589056	589167	589279	589391	589503	589615	589726	589838	112
389	589950	590061	590173	590284	590396	590507	590619	590730	590842	590953	112
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9	D.	1	2	3	4	5	6	7	8	9
112	11	22	34	45	56	67	78	90	101	122	12	24	37	49	61	73	85	98	110
114	11	23	34	46	57	68	80	91	103	124	12	25	37	50	62	74	87	99	112
116	12	23	35	46	58	70	81	93	104	126	13	25	38	50	63	76	88	101	113
118	12	24	35	47	59	71	83	94	106	128	13	26	38	51	64	77	90	102	115
120	12	24	36	48	60	72	84	96	108	130	13	26	39	52	65	78	01	104	117

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 3900 to 4449 — **Log. 591065 to 648262**

No.	0	1	2	3	4	5	6	7	8	9	D.
390	591065	591176	591287	591399	591510	591621	591732	591843	591955	592066	111
391	592177	592288	592399	592510	592621	592732	592843	592954	593064	593175	111
392	593286	593397	593508	593618	593729	593840	593950	594061	594171	594282	111
393	594393	594503	594614	594724	594834	594945	595055	595165	595276	595386	110
394	595496	595606	595717	595827	595937	596047	596157	596267	596377	596487	110
395	596597	596707	596817	596927	597037	597146	597256	597366	597476	597586	110
396	597695	597805	597914	598024	598134	598243	598353	598462	598572	598681	110
397	598791	598900	599009	599119	599228	599337	599446	599556	599665	599774	109
398	599883	599992	600101	600210	600319	600428	600537	600646	600755	600864	109
399	600973	601082	601191	601299	601408	601517	601625	601734	601843	601951	109
400	602060	602169	602277	602386	602494	602603	602711	602819	602928	603036	108
401	603144	603253	603361	603469	603577	603686	603794	603902	604010	604118	108
402	604226	604334	604442	604550	604658	604766	604874	604982	605089	605197	108
403	605305	605413	605521	605628	605736	605844	605951	606059	606166	606274	108
404	606381	606489	606596	606704	606811	606919	607026	607133	607241	607348	107
405	607455	607562	607669	607777	607884	607991	608098	608205	608312	608419	107
406	608526	608633	608740	608847	608954	609061	609167	609274	609381	609488	107
407	609594	609701	609808	609914	610021	610128	610234	610341	610447	610554	107
408	610660	610767	610873	610979	611086	611192	611298	611405	611511	611617	106
409	611723	611829	611936	612042	612148	612254	612360	612466	612572	612678	106
410	612784	612890	612996	613102	613207	613313	613419	613525	613630	613736	106
411	613842	613947	614053	614159	614264	614370	614475	614581	614686	614792	106
412	614897	615003	615108	615213	615319	615424	615529	615634	615740	615845	105
413	615950	616055	616160	616265	616370	616476	616581	616686	616790	616895	105
414	617000	617105	617210	617315	617420	617525	617629	617734	617839	617943	105
415	618048	618153	618257	618362	618466	618571	618676	618780	618884	618989	105
416	619093	619198	619302	619406	619511	619615	619719	619824	619928	620032	104
417	620136	620240	620344	620448	620552	620656	620760	620864	620968	621072	104
418	621176	621280	621384	621488	621592	621695	621799	621903	622007	622110	104
419	622214	622318	622421	622525	622628	622732	622835	622939	623042	623146	104
420	623249	523353	623456	623559	623663	623766	623869	623973	624076	624179	103
421	624282	624385	624488	624591	624695	624798	624901	625004	625107	625210	103
422	625312	625415	625518	625621	625724	625827	625929	626032	626135	626238	103
423	626340	626443	626546	626648	626751	626853	626956	627058	627161	627263	103
424	627366	627468	627571	627673	627775	527878	627980	628082	628185	628287	102
425	628389	628491	628593	628695	628797	628900	629002	629104	629206	629308	102
426	629410	629512	629613	629715	629817	629919	630021	630123	630224	630326	102
427	630428	630530	630631	630733	630835	630936	631038	631139	631241	631342	102
428	631444	631545	631647	631748	631849	631951	632052	632153	632255	632356	101
429	632457	632559	632660	632761	632862	632963	633064	633165	633266	633367	101
430	633468	633569	633670	633771	633872	633973	634074	634175	634276	634376	101
431	634477	634578	634679	634779	634880	634981	635081	635182	635283	635383	101
432	635484	635584	635685	635785	635886	635986	636087	636187	636287	636388	100
433	636488	636588	636688	636789	636889	636989	637089	637189	637290	637390	100
434	637490	637590	637690	637790	637890	637990	638090	638190	638290	638389	100
435	638489	638589	638689	638789	638888	638988	639088	639188	639287	639387	100
436	639486	639586	639686	639785	639885	639984	640084	640183	640283	640382	99
437	640481	640581	640680	640779	640879	640978	641077	641177	641276	641375	99
438	641474	641573	641672	641771	641871	641970	642069	642168	642267	642366	99
439	642465	642563	642662	642761	642860	642959	643058	643156	643255	643354	99
440	643453	643551	643650	643749	643847	643946	644044	644143	644242	644340	59
441	644439	644537	644636	644734	644832	644931	645029	645127	645226	645324	98
442	645422	645521	645619	645717	645815	645913	646011	646110	646208	646306	98
443	646404	646502	646600	646698	646796	646894	646992	647089	647187	647285	98
444	647383	647481	647579	647676	647774	647872	647969	648067	648165	648262	98
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9	D.	1	2	3	4	5	6	7	8	9
98	10	20	29	39	49	59	69	78	88	106	11	21	32	42	53	64	74	85	95
100	10	20	30	40	50	60	70	80	90	108	11	22	32	43	54	65	76	86	97
102	10	20	31	41	51	61	71	82	92	110	11	22	33	44	55	66	77	88	99
104	10	21	31	42	52	62	73	83	94	112	11	22	34	45	56	67	78	90	101

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 4450 to 4999 • Log. 648360 to 698883

No.	0	1	2	3	4	5	6	7	8	9	D.
445	648360	648458	648555	648653	648750	648848	648945	649043	649140	649237	97
446	649335	649432	649530	649627	649724	649821	649919	650016	650113	650210	97
447	650308	650405	650502	650599	650696	650793	650890	650987	651084	651181	97
448	651278	651375	651472	651569	651666	651762	651859	651956	652053	652150	97
449	652246	652343	652440	652536	652633	652730	652826	652923	653019	653116	97
450	653213	653309	653405	653502	653598	653695	653791	653888	653984	654080	96
451	654177	654273	654369	654465	654562	654658	654754	654850	654946	655042	96
452	655138	655235	655331	655427	655523	655619	655715	655810	655906	656002	96
453	656098	656194	656290	656386	656482	656577	656673	656769	656864	656960	96
454	657056	657152	657247	657343	657438	657534	657629	657725	657820	657916	96
455	658011	658107	658202	658298	658393	658488	658584	658679	658774	658870	95
456	658965	659060	659155	659250	659346	659441	659536	659631	659726	659821	95
457	659916	660011	660106	660201	660295	660391	660486	660581	660676	660771	95
458	660865	660960	661055	661150	661245	661339	661434	661529	661623	661718	95
459	661813	661907	662002	662096	662191	662286	662380	662475	662569	662663	95
460	662758	662852	662947	663041	663135	663230	663324	663418	663512	663607	94
461	663701	663795	663889	663983	664078	664172	664266	664360	664454	664548	94
462	664642	664736	664830	664924	665018	665112	665206	665299	665393	665487	94
463	665581	665675	665769	665862	665956	666050	666143	666237	666331	666424	94
464	666518	666612	666705	666799	666892	666986	667079	667173	667266	667360	94
465	667453	667546	667640	667733	667826	667920	668013	668106	668199	668293	93
466	668386	668479	668572	668665	668759	668852	668945	669038	669131	669224	93
467	669317	669410	669503	669596	669689	669782	669875	669967	670060	670153	93
468	670246	670339	670431	670524	670617	670710	670802	670895	670988	671080	93
469	671173	671265	671358	671451	671543	671636	671728	671821	671913	672005	93
470	672098	672190	672283	672375	672467	672560	672652	672744	672836	672929	92
471	673021	673113	673205	673297	673390	673482	673574	673666	673758	673850	92
472	673942	674034	674126	674218	674310	674402	674494	674586	674677	674769	92
473	674861	674953	675045	675137	675228	675320	675412	675503	675595	675687	92
474	675778	675870	675962	676053	676145	676236	676328	676419	676511	676602	92
475	676694	676785	676876	676968	677059	677151	677242	677333	677424	677516	91
476	677607	677698	677789	677881	677972	678063	678154	678245	678336	678427	91
477	678518	678609	678700	678791	678882	678973	679064	679155	679246	679337	91
478	679428	679519	679610	679700	679791	679882	679973	680063	680154	680245	91
479	680336	680426	680517	680607	680698	680789	680879	680970	681060	681151	91
480	681241	681332	681422	681513	681603	681693	681784	681874	681964	682055	90
481	682145	682235	682326	682416	682506	682596	682686	682777	682867	682957	90
482	683047	683137	683227	683317	683407	683497	683587	683677	683767	683857	90
483	683947	684037	684127	684217	684307	684396	684486	684576	684666	684756	90
484	684845	684935	685025	685114	685204	685294	685383	685473	685563	685652	90
485	685742	685831	685921	686010	686100	686189	686279	686368	686458	686547	89
486	686636	686726	686815	686904	686994	687083	687172	687261	687351	687440	89
487	687529	687618	687707	687796	687886	687975	688064	688153	688242	688331	89
488	688420	688509	688598	688687	688776	688865	688953	689042	689131	689220	89
489	689309	689398	689486	689575	689664	689753	689841	689930	690019	690107	89
490	690196	690285	690373	690462	690550	690639	690728	690816	690905	690993	89
491	691081	691170	691258	691347	691435	691524	691612	691700	691789	691877	88
492	691965	692053	692142	692230	692318	692406	692494	692583	692671	692759	88
493	692847	692935	693023	693111	693199	693287	693375	693463	693551	693639	88
494	693727	693815	693903	693991	694078	694166	694254	694342	694430	694517	88
495	694605	694693	694781	694868	694956	695044	695131	695219	695307	695394	88
496	695482	695569	695657	695744	695832	695919	696007	696094	696182	696269	87
497	696356	696444	696531	696618	696706	696793	696880	696968	697055	697142	87
498	697229	697317	697404	697491	697578	697665	697752	697839	697926	698014	87
499	698101	698188	698275	698362	698449	698535	698622	698709	698796	698883	87
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9	D.	1	2	3	4	5	6	7	8	9
88	9	18	26	35	44	53	62	70	79	93	9	19	28	37	46	56	65	74	84
89	9	18	27	36	44	53	62	71	80	94	9	19	28	38	47	56	66	75	85
90	9	18	27	36	45	54	63	72	81	95	9	19	28	38	47	57	66	76	86
91	9	18	27	36	45	55	64	73	82	96	10	19	29	38	48	58	67	77	86
92	9	18	28	37	46	55	64	74	83	97	10	19	29	39	48	58	68	78	87

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 5000 to 5549 **Log. 698970 to 744215**

No.	0	1	2	3	4	5	6	7	8	9	D.
500	698970	699057	699144	699231	699317	699404	699491	699578	699664	699751	87
501	699838	699924	700011	700098	700184	700271	700358	700444	700531	700617	87
502	700704	700790	700877	700963	701050	701136	701222	701309	701395	701482	86
503	701568	701654	701741	701827	701913	701999	702086	702172	702258	702344	86
504	702431	702517	702603	702689	702775	702861	702947	703033	703119	703205	86
505	703291	703377	703463	703549	703635	703721	703807	703893	703979	704065	86
506	704151	704236	704322	704408	704494	704579	704665	704751	704837	704922	86
507	705008	705094	705179	705265	705350	705436	705522	705607	705693	705778	86
508	705864	705949	706035	706120	706206	706291	706376	706462	706547	706632	85
509	706718	706803	706888	706974	707059	707144	707229	707315	707400	707485	85
510	707570	707655	707740	707826	707911	707996	708081	708166	708251	708336	85
511	708421	708506	708591	708676	708761	708846	708931	709015	709100	709185	85
512	709270	709355	709440	709524	709609	709694	709779	709863	709948	710033	85
513	710117	710202	710287	710371	710456	710540	710625	710710	710794	710879	85
514	710963	711048	711132	711217	711301	711385	711470	711554	711639	711723	84
515	711807	711892	711976	712060	712144	712229	712313	712397	712481	712566	84
516	712650	712734	712818	712902	712986	713070	713154	713238	713323	713407	84
517	713491	713575	713659	713742	713826	713910	713994	714078	714162	714246	84
518	714330	714414	714497	714581	714665	714749	714833	714916	715000	715084	84
519	715167	715251	715335	715418	715502	715586	715669	715753	715836	715920	84
520	716003	716087	716170	716254	716337	716421	716504	716588	716671	716754	83
521	716838	716921	717004	717088	717171	717254	717338	717421	717504	717587	83
622	717671	717754	717837	717920	718003	718086	718169	718253	718336	718419	83
523	718502	718585	718668	718751	718834	718917	719000	719083	719165	719248	83
524	719331	719414	719497	719580	719663	719745	719828	719911	719994	720077	83
525	720159	720242	720325	720407	720490	720573	720655	720738	720821	720903	83
526	720986	721068	721151	721233	721316	721398	721481	721563	721646	721728	82
527	721811	721893	721975	722058	722140	722222	722305	722387	722469	722552	82
528	722634	722716	722798	722881	722963	723045	723127	723209	723291	723374	82
529	723456	723538	723620	723702	723784	723866	723948	724030	724112	724194	82
530	724276	724358	724440	724522	724604	724685	724767	724849	724931	725013	82
531	725095	725176	725258	725340	725422	725503	725585	725667	725748	725830	82
532	725912	725993	726075	726156	726238	726320	726401	726483	726564	726646	82
533	726727	726809	726890	726972	727053	727134	727216	727297	727379	727460	81
534	727541	727623	727704	727785	727866	727948	728029	728110	728191	728273	81
535	728354	728435	728516	728597	728678	728759	728841	728922	729003	729084	81
536	729165	729246	729327	729408	729489	729570	729651	729732	729813	729893	81
537	729974	730055	730136	730217	730298	730378	730459	730540	730621	730702	81
538	730782	730863	730944	731024	731105	731186	731266	731347	731428	731508	81
539	731589	731669	731750	731830	731911	731991	732072	732152	732233	732313	81
540	732394	732474	732555	732635	732715	732796	732876	732956	733037	733117	80
541	733197	733278	733358	733438	733518	733598	733679	733759	733839	733919	80
542	733999	734079	734160	734240	734320	734400	734480	734560	734640	734720	80
543	734800	734880	734960	735040	735120	735200	735279	735359	735439	735519	80
544	735599	735679	735759	735838	735918	735998	736078	736157	736237	736317	80
545	736397	736476	736556	736635	736715	736795	736874	736954	737034	737113	80
546	737193	737272	737352	737431	737511	737590	737670	737749	737829	737908	79
547	737987	738067	738146	738225	738305	738384	738463	738543	738622	738701	79
548	738781	738860	738939	739018	739097	739177	739256	739335	739414	739493	79
549	739572	739651	739731	739810	739889	739968	740047	740126	740205	740284	79
550	740363	740442	740521	740600	740678	740757	740836	740915	740994	741073	79
551	741152	741230	741309	741388	741467	741546	741624	741703	741782	741860	79
552	741939	742018	742096	742175	742254	742332	742411	742489	742568	742647	79
553	742725	742804	742882	742961	743039	743118	743196	743275	743353	743431	78
554	743510	743588	743667	743745	743823	743902	743980	744058	744136	744215	78
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9	D.	1	2	3	4	5	6	7	8	9
78	8	16	23	31	39	47	55	62	70	83	8	17	25	33	41	50	58	66	75
79	8	16	24	32	39	47	55	63	71	84	8	17	25	34	42	50	59	67	76
80	8	16	24	32	40	48	56	64	72	85	8	17	25	34	42	51	59	68	76
81	8	16	24	32	40	49	57	65	73	86	9	17	26	34	43	52	60	69	77
82	8	16	25	33	41	49	57	66	74	87	9	17	26	35	43	52	61	70	78

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 5550 to 6099 **Log. 744293 to 785259**

No.	0	1	2	3	4	5	6	7	8	9	D.
555	744293	744371	744449	744528	744606	744684	744762	744840	744919	744997	78
556	745075	745153	745231	745309	745387	745465	745543	745621	745699	745777	78
557	745855	745933	746011	746089	746167	746245	746323	746401	746479	746556	78
558	746634	746712	746790	746868	746945	747023	747101	747179	747256	747334	78
559	747412	747489	747567	747645	747722	747800	747878	747955	748033	748110	78
560	748188	748266	748343	748421	748498	748576	748653	748731	748808	748885	77
561	748963	749040	749118	749195	749272	749350	749427	749504	749582	749659	77
562	749736	749814	749891	749968	750045	750123	750200	750277	750354	750431	77
563	750508	750586	750663	750740	750817	750894	750971	751048	751125	751202	77
564	751279	751356	751433	751510	751587	751664	751741	751818	751895	751972	77
565	752048	752125	752202	752279	752356	752433	752509	752586	752663	752740	77
566	752816	752893	752970	753047	753123	753200	753277	753353	753430	753506	77
567	753583	753660	753736	753813	753889	753966	754042	754119	754195	754272	77
568	754348	754425	754501	754578	754654	754730	754807	754883	754960	755036	76
569	755112	755189	755265	755341	755417	755494	755570	755646	755722	755799	76
570	755875	755951	756027	756103	756180	756256	756332	756408	756484	756560	76
571	756636	756712	756788	756864	756940	757016	757092	757168	757244	757320	76
572	757396	757472	757548	757624	757700	757775	757851	757927	758003	758079	76
573	758155	758230	758306	758382	758458	758533	758609	758685	758761	758836	76
574	758912	758988	759063	759139	759214	759290	759366	759441	759517	759592	76
575	759668	759743	759819	759894	759970	760045	760121	760196	760272	760347	75
576	760422	760498	760573	760649	760724	760799	760875	760950	761025	761101	75
577	761176	761251	761326	761402	761477	761552	761627	761702	761778	761853	75
578	761928	762003	762078	762153	762228	762303	762378	762453	762529	762604	75
579	762679	762754	762829	762904	762978	763053	763128	763203	763278	763353	75
580	763428	763503	763578	763653	763727	763802	763877	763952	764027	764101	75
581	764176	764251	764326	764400	764475	764550	764624	764699	764774	764848	75
582	764923	764998	765072	765147	765221	765296	765370	765445	765520	765594	75
583	765669	765743	765818	765892	765966	766041	766115	766190	766264	766338	74
584	766413	766487	766562	766636	766710	766785	766859	766933	767007	767082	74
585	767156	767230	767304	767379	767453	767527	767601	767675	767749	767823	74
586	767898	767972	768046	768120	768194	768268	768342	768416	768490	768564	74
587	768638	768712	768786	768860	768934	769008	769082	769156	769230	769303	74
588	769377	769451	769525	769599	769673	769746	769820	769894	769968	770042	74
589	770115	770189	770263	770336	770410	770484	770557	770631	770705	770778	74
590	770852	770926	770999	771073	771146	771220	771293	771367	771440	771514	74
591	771587	771661	771734	771808	771881	771955	772028	772102	772175	772248	73
592	772322	772395	772468	772542	772615	772688	772762	772835	772908	772981	73
593	773055	773128	773201	773274	773348	773421	773494	773567	773640	773713	73
594	773786	773860	773933	774006	774079	774152	774225	774298	774371	774444	73
595	774517	774590	774663	774736	774809	774882	774955	775028	775100	775173	73
596	775246	775319	775392	775465	775538	775610	775683	775756	775829	775902	73
597	775974	776047	776120	776193	776265	776338	776411	776483	776556	776629	73
598	776701	776774	776846	776919	776992	777064	777137	777209	777282	777354	73
599	777427	777499	777572	777644	777717	777789	777862	777934	778006	778079	72
600	778151	778224	778296	778368	778441	778513	778585	778658	778730	778802	72
601	778874	778947	779019	779091	779163	779236	779308	779380	779452	779524	72
602	779596	779669	779741	779813	779885	779957	780029	780101	780173	780245	72
603	780317	780389	780461	780533	780605	780677	780749	780821	780893	780965	72
604	781037	781109	781181	781253	781324	781396	781468	781540	781612	781684	72
605	781755	781827	781899	781971	782042	782114	782186	782258	782329	782401	72
606	782473	782544	782616	782688	782759	782831	782902	782974	783046	783117	72
607	783189	783260	783332	783403	783475	783546	783618	783689	783761	783832	71
608	783904	783975	784046	784118	784189	784261	784332	784403	784475	784546	71
609	784617	784689	784760	784831	784902	784974	785045	785116	785187	785259	71
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9	D.	1	2	3	4	5	6	7	8	9
71	7	14	21	28	35	43	50	57	64	75	7	15	22	30	37	45	52	60	67
72	7	14	22	29	36	43	50	58	65	76	8	15	23	30	38	46	53	61	68
73	7	15	22	29	36	44	51	58	66	77	8	15	23	31	38	46	54	62	69
74	7	15	22	30	37	44	52	59	67	78	8	16	23	31	39	47	55	62	70

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 6100 to 6649 **Log. 785330 to 822756**

No.	0	1	2	3	4	5	6	7	8	9	D.
610	785330	785401	785472	785543	785615	785686	785757	785828	785899	785970	71
611	786041	786112	786183	786254	786325	786396	786467	786538	786609	786680	71
612	786751	786822	786893	786964	787035	787106	787177	787248	787319	787390	71
613	787460	787531	787602	787673	787744	787815	787885	787956	788027	788098	71
614	788168	788239	788310	788381	788451	788522	788593	788663	788734	788804	71
615	788875	788946	789016	789087	789157	789228	789299	789369	789440	789510	71
616	789581	789651	789722	789792	789863	789933	790004	790074	790144	790215	70
617	790285	790356	790426	790496	790567	790637	790707	790778	790848	790918	70
618	790988	791059	791129	791199	791269	791340	791410	791480	791550	791620	70
619	791691	791761	791831	791901	791971	792041	792111	792181	792252	792322	70
620	792392	792462	792532	792602	792672	792742	792812	792882	792952	793022	70
621	793092	793162	793231	793301	793371	793441	793511	793581	793651	793721	70
622	793790	793860	793930	794000	794070	794139	794209	794279	794349	794418	70
623	794488	794558	794627	794697	794767	794836	794906	794976	795045	795115	70
624	795185	795254	795324	795393	795463	795532	795602	795672	795741	795811	70
625	795880	795949	796019	796088	796158	796227	796297	796366	796436	796505	69
626	796574	796644	796713	796782	796852	796921	796990	797060	797129	797198	69
627	797268	797337	797406	797475	797545	797614	797683	797752	797821	797890	69
628	797960	798029	798098	798167	798236	798305	798374	798443	798513	798582	69
629	798651	798720	798789	798858	798927	798996	799065	799134	799203	799272	69
630	799341	799409	799478	799547	799616	799685	799754	799823	799892	799961	69
631	800029	800098	800167	800236	800305	800373	800442	800511	800580	800648	69
632	800717	800786	800854	800923	800992	801061	801129	801198	801266	801335	69
633	801404	801472	801541	801609	801678	801747	801815	801884	801952	802021	69
634	802089	802158	802226	802295	802363	802432	802500	802568	802637	802705	69
635	802774	802842	802910	802979	803047	803116	803184	803252	803321	803389	68
636	803457	803525	803594	803662	803730	803798	803867	803935	804003	804071	68
637	804139	804208	804276	804344	804412	804480	804548	804616	804685	804753	68
638	804821	804889	804957	805025	805093	805161	805229	805297	805365	805433	68
639	805501	805569	805637	805705	805773	805841	805908	805976	806044	806112	68
640	806180	806248	806316	806384	806451	806519	806587	806655	806723	806790	68
641	806858	806926	806994	807061	807129	807197	807264	807332	807400	807467	68
642	807535	807603	807670	807738	807806	807873	807941	808008	808076	808143	68
643	808211	808279	808346	808414	808481	808549	808616	808684	808751	808818	67
644	808886	808953	809021	809088	809156	809223	809290	809358	809425	809492	67
645	809560	809627	809694	809762	809829	809896	809964	810031	810098	810165	67
646	810233	810300	810367	810434	810501	810569	810636	810703	810770	810837	67
647	810904	810971	811039	811106	811173	811240	811307	811374	811441	811508	67
648	811575	811642	811709	811776	811843	811910	811977	812044	812111	812178	67
649	812245	812312	812379	812445	812512	812579	812646	812713	812780	812847	67
650	812913	812980	813047	813114	813181	813247	813314	813381	813448	813514	67
651	813581	813648	813714	813781	813848	813914	813981	814048	814114	814181	67
652	814248	814314	814381	814447	814514	814581	814647	814714	814780	814847	67
653	814913	814980	815046	815113	815179	815246	815312	815378	815445	815511	66
654	815578	815644	815711	815777	815843	815910	815976	816042	816109	816175	66
655	816241	816308	816374	816440	816506	816573	816639	816705	816771	816838	66
656	816904	816970	817036	817102	817169	817235	817301	817367	817433	817499	66
657	817565	817631	817698	817764	817830	817896	817962	818028	818094	818160	66
658	818226	818292	818358	818424	818490	818556	818622	818688	818754	818820	66
659	818885	818951	819017	819083	819149	819215	819281	819346	819412	819478	66
660	819544	819610	819676	819741	819807	819873	819939	820004	820070	820136	66
661	820201	820267	820333	820399	820464	820530	820595	820661	820727	820792	66
662	820858	820924	820989	821055	821120	821186	821251	821317	821382	821448	66
663	821514	821579	821645	821710	821775	821841	821906	821972	822037	822103	65
664	822168	822233	822299	822364	822430	822495	822560	822626	822691	822756	65
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9	D.	1	2	3	4	5	6	7	8	9
65	6	13	19	26	32	39	45	52	58	68	7	14	20	27	34	41	48	54	61
66	7	13	20	26	33	40	46	53	59	69	7	14	21	28	34	41	48	55	62
67.	7	13	20	27	33	40	47	54	60	70	7	14	21	28	35	42	49	56	63
68	7	14	20	27	34	41	48	54	61	71	7	4	21	28	35	43	50	57	64

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 6650 to 7199 **Log. 822822 to 857272**

No.	0	1	2	3	4	5	6	7	8	9	D.
665	822822	822887	822952	823018	823083	823148	823213	823279	823344	823409	65
666	823474	823539	823605	823670	823735	823800	823865	823930	823996	824061	65
667	824126	824191	824256	824321	824386	824451	824516	824581	824646	824711	65
668	824776	824841	824906	824971	825036	825101	825166	825231	825296	825361	65
669	825426	825491	825556	825621	825686	825751	825815	825880	825945	826010	65
670	826075	826140	826204	826269	826334	826399	826464	826528	826593	826658	65
671	826723	826787	826852	826917	826981	827046	827111	827175	827240	827305	65
672	827369	827434	827499	827563	827628	827692	827757	827821	827886	827951	65
673	828015	828080	828144	828209	828273	828338	828402	828467	828531	828595	64
674	828660	828724	828789	828853	828918	828982	829046	829111	829175	829239	64
675	829304	829368	829432	829497	829561	829625	829690	829754	829818	829882	64
676	829947	830011	830075	830139	830204	830268	830332	830396	830460	830525	64
677	830589	830653	830717	830781	830845	830909	830973	831037	831102	831166	64
678	831230	831294	831358	831422	831486	831550	831614	831678	831742	831806	64
679	831870	831934	831998	832062	832126	832189	832253	832317	832381	832445	64
680	832509	832573	832637	832700	832764	832828	832892	832956	833020	833083	64
681	833147	833211	833275	833338	833402	833466	833530	833593	833657	833721	64
682	833784	833848	833912	833975	834039	834103	834166	834230	834294	834357	64
683	834421	834484	834548	834611	834675	834739	834802	834866	834929	834993	64
684	835056	835120	835183	835247	835310	835373	835437	835500	835564	835627	63
685	835691	835754	835817	835881	835944	836007	836071	836134	836197	836261	63
686	836324	836387	836451	836514	836577	836641	836704	836767	836830	836894	63
687	836957	837020	837083	837146	837210	837273	837336	837399	837462	837525	63
688	837588	837652	837715	837778	837841	837904	837967	838030	838093	838156	63
689	838219	838282	838345	838408	838471	838534	838597	838660	838723	838786	63
690	838849	838912	838975	839038	839101	839164	839227	839289	839352	839415	63
691	839478	839541	839604	839667	839729	839792	839855	839918	849981	840043	63
692	840106	840169	840232	840294	840357	840420	840482	840545	840608	840671	63
693	840733	840796	840859	840921	840984	841046	841109	841172	841234	841297	63
694	841359	841422	841485	841547	841610	841672	841735	841797	841860	841922	63
695	841985	842047	842110	842172	842235	842297	842360	842422	842484	842547	62
696	842609	842672	842734	842796	842859	842921	842983	843046	843108	843170	62
697	843233	843295	843357	843420	843482	843544	843606	843669	843731	843793	62
698	843855	843918	843980	844042	844104	844166	844229	844291	844353	844415	62
699	844477	844539	844601	844664	844726	844788	844850	844912	844974	845036	62
700	845098	845160	845222	845284	845346	845408	845470	845532	845594	845656	62
701	845718	845780	845842	845904	845966	846028	846090	846151	846213	846275	62
702	846337	846399	846461	846523	846585	846646	846708	846770	846832	846894	62
703	846955	847017	847079	847141	847202	847264	847326	847388	847449	847511	62
704	847573	847634	847696	847758	847819	847881	847943	848004	848066	848128	62
705	848189	848251	848312	848374	848435	848497	848559	848620	848682	848743	62
706	848805	848866	848928	848989	849051	849112	849174	849235	849297	849358	61
707	849419	849481	849542	849604	849665	849726	849788	849849	849911	849972	61
708	850033	850095	850156	850217	850279	850340	850401	850462	850524	850585	61
709	850646	850707	850769	850830	850891	850952	851014	851075	851136	851197	61
710	851258	851320	851381	851442	851503	851564	851625	851686	851747	851809	61
711	851870	851931	851992	852053	852114	852175	852236	852297	852358	852419	61
712	852480	852541	852602	852663	852724	852785	852846	852907	852968	853029	61
713	853090	853150	853211	853272	853333	853394	853455	853516	853577	853637	61
714	853698	853759	853820	853881	853941	854002	854063	854124	854185	854245	61
715	854306	854367	854428	854488	854549	854610	854670	854731	854792	854852	61
716	854913	854974	855034	855095	855156	855216	855277	855337	855398	855459	61
717	855519	855580	855640	855701	855761	855822	855882	855943	856003	856064	61
718	856124	856185	856245	856306	856366	856427	856487	856548	856608	856668	60
719	856729	856789	856850	856910	856970	857031	857091	857152	857212	857272	60
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9	D	1	2	3	4	5	6	7	8	9
60	6	12	18	24	30	36	42	48	54	63	6	13	19	25	31	38	44	50	57
61	6	12	18	24	30	37	43	49	55	64	6	13	19	26	32	38	45	51	58
62	6	12	19	25	31	37	43	50	56	65	6	13	19	26	32	39	45	52	58

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 7200 to 7749 — Log. 857332 to 889246

No.	0	1	2	3	4	5	6	7	8	9	D.
720	857332	857393	857453	857513	857574	857634	857694	857755	857815	857875	60
721	857935	857995	858056	858116	858176	858236	858297	858357	858417	858477	60
722	858537	858597	858657	858718	858778	858838	858898	858958	859018	859078	60
723	859138	859198	859258	859318	859379	859439	859499	859559	859619	859679	60
724	859739	859799	859859	859918	859978	860038	860098	860158	860218	860278	60
725	860338	860398	860458	860518	860578	860637	860697	860757	860817	860877	60
726	860937	860996	861056	861116	861176	861236	861295	861355	861415	861475	60
727	861534	861594	861654	861714	861773	861833	861893	861952	862012	862072	60
728	862131	862191	862251	862310	862370	862430	862489	862549	862608	862668	60
729	862728	862787	862847	862906	862966	863025	863085	863144	863204	863263	60
730	863323	863382	863442	863501	863561	863620	863680	863739	863799	863858	59
731	863917	863977	864036	864096	864155	864214	864274	864333	864392	864452	59
732	864511	864570	864630	864689	864748	864808	864867	864926	864985	865045	59
733	865104	865163	865222	865282	865341	865400	865459	865519	865578	865637	59
734	865696	865755	865814	865874	865933	865992	866051	866110	866169	866228	59
735	866287	866346	866405	866465	866524	866583	866642	866701	866760	866819	59
736	866878	866937	866996	867055	867114	867173	867232	867291	867350	867409	59
737	867467	867526	867585	867644	867703	867762	867821	867880	867939	867998	59
738	868056	868115	868174	868233	868292	868350	868409	868468	868527	868586	59
739	868644	868703	868762	868821	868879	868938	868997	869056	869114	869173	59
740	869232	869290	869349	869408	869466	869525	869584	869642	869701	869760	59
741	869818	869877	869935	869994	870053	870111	870170	870228	870287	870345	59
742	870404	870462	870521	870579	870638	870696	870755	870813	870872	870930	58
743	870989	871047	871106	871164	871223	871281	871339	871398	871456	871515	58
744	871573	871631	871690	871748	871806	871865	871923	871981	872040	872098	58
745	872156	872215	872273	872331	872389	872448	872506	872564	872622	872681	58
746	872739	872797	872855	872913	872972	873030	873088	873146	873204	873262	58
747	873321	873379	873437	873495	873553	873611	873669	873727	873785	873844	58
748	873902	873960	874018	874076	874134	874192	874250	874308	874366	874424	58
749	874482	874540	874598	874656	874714	874772	874830	874888	874945	875003	58
750	875061	875119	875177	875235	875293	875351	875409	875466	875524	875582	58
751	875640	875698	875756	875813	875871	875929	875987	876045	876102	876160	58
752	876218	876276	876333	876391	876449	876507	876564	876622	876680	876737	58
753	876795	876853	876910	876968	877026	877083	877141	877199	877256	877314	58
754	877371	877429	877487	877544	877602	877659	877717	877774	877832	877889	58
755	877947	878004	878062	878119	878177	878234	878292	878349	878407	878464	57
756	878522	878579	878637	878694	878752	878809	878866	878924	878981	879039	57
757	879096	879153	879211	879268	879325	879383	879440	879497	879555	879612	57
758	879669	879726	879784	879841	879898	879956	880013	880070	880127	880185	57
759	880242	880299	880356	880413	880471	880528	880585	880642	880699	880756	57
760	880814	880871	880928	880985	881042	881099	881156	881213	881271	881328	57
761	881385	881442	881499	881556	881613	881670	881727	881784	881841	881898	57
762	881955	882012	882069	882126	882183	882240	882297	882354	882411	882468	57
763	882525	882581	882638	882695	882752	882809	882866	882923	882980	883037	57
764	883093	883150	883207	883264	883321	883377	883434	883491	883548	883605	57
765	883661	883718	883775	883832	883888	883945	884002	884059	884115	884172	57
766	884229	884285	884342	884399	884455	884512	884569	884625	884682	884739	57
767	884795	884852	884909	884965	885022	885078	885135	885192	885248	885305	57
768	885361	885418	885474	885531	885587	885644	885700	885757	885813	885870	57
769	885926	885983	886039	886096	886152	886200	886265	886321	886378	886434	56
770	886491	886547	886604	886660	886716	886773	886829	886885	886942	886998	56
771	887054	887111	887167	887223	887280	887336	887392	887449	887505	887561	56
772	887617	887674	887730	887786	887842	887898	887955	888011	888067	888123	56
773	888179	888236	888292	888348	888404	888460	888516	888573	888629	888685	56
774	888741	888797	888853	888909	888965	889021	889077	889134	889190	889246	56
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9
56	6	11	17	22	28	34	39	45	50
57	6	11	17	23	28	34	40	46	51
58	6	12	17	23	29	35	41	46	52

D.	1	2	3	4	5	6	7	8	9
59	6	12	18	24	29	35	41	47	53
60	6	12	18	24	30	36	42	48	54

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 7750 to 8299 **Log. 889302 to 919026**

No.	0	1	2	3	4	5	6	7	8	9	D.
775	889302	889358	889414	889470	889526	889582	889638	889694	889750	889806	56
776	889862	889918	889974	890030	890086	890141	890197	890253	890309	890365	56
777	890421	890477	890533	890589	890645	890700	890756	890812	890868	890924	56
778	890980	891035	891091	891147	891203	891259	891314	891370	891426	891482	56
779	891537	891593	891649	891705	891760	891816	891872	891928	891983	892039	56
780	892095	892150	892206	892262	892317	892373	892429	892484	892540	892595	56
781	892651	892707	892762	892818	892873	892929	892985	893040	893096	893151	56
782	893207	893262	893318	893373	893429	893484	893540	893595	893651	893706	56
783	893762	893817	893873	893928	893984	894039	894094	894150	894205	894261	55
784	894316	894371	894427	894482	894538	894593	894648	894704	894759	894814	55
785	894870	894925	894980	895036	895091	895146	895201	895257	895312	895367	55
786	895423	895478	895533	895588	895644	895699	895754	895809	895864	895920	55
787	895975	896030	896085	896140	896195	896251	896306	896361	896416	896471	55
788	896526	896581	896636	896692	896747	896802	896857	896912	896967	897022	55
789	897077	897132	897187	897242	897297	897352	897407	897462	897517	897572	55
790	897627	897682	897737	897792	897847	897902	897957	898012	898067	898122	55
791	898176	898231	898286	898341	898396	898451	898506	898561	898615	898670	55
792	898725	898780	898835	898890	898944	898999	899054	899109	899164	899218	55
793	899273	899328	899383	899437	899492	899547	899602	899656	899711	899766	55
794	899821	899875	899930	899985	900039	900094	900149	900203	900258	900312	55
795	900367	900422	900476	900531	900586	900640	900695	900749	900804	900859	55
796	900913	900968	901022	901077	901131	901186	901240	901295	901349	901404	55
797	901458	901513	901567	901622	901676	901731	901785	901840	901894	901948	54
798	902003	902057	902112	902166	902221	902275	902329	902384	902438	902492	54
799	902547	902601	902655	902710	902764	902818	902873	902927	902981	903036	54
800	903090	903144	903199	903253	903307	903361	903416	903470	903524	903578	54
801	903633	903687	903741	903795	903849	903904	903958	904012	904066	904120	54
802	904174	904229	904283	904337	904391	904445	904499	904553	904607	904661	54
803	904716	904770	904824	904878	904932	904986	905040	905094	905148	905202	54
804	905256	905310	905364	905418	905472	905526	905580	905634	905688	905742	54
805	905796	905850	905904	905958	906012	906066	906119	906173	906227	906281	54
806	906335	906389	906443	906497	906551	906604	906658	906712	906766	906820	54
807	906874	906927	906981	907035	907089	907143	907196	907250	907304	907358	54
808	907411	907465	907519	907573	907626	907680	907734	907787	907841	907895	54
809	907949	908002	908056	908110	908163	908217	908270	908324	908378	908431	54
810	908485	908539	908592	908646	908699	908753	908807	908860	908914	908967	54
811	909021	909074	909128	909181	909235	909289	909342	909396	909449	909503	54
812	909556	909610	909663	909716	909770	909823	909877	909930	909984	910037	53
813	910091	910144	910197	910251	910304	910358	910411	910464	910518	910571	53
814	910624	910678	910731	910784	910838	910891	910944	910998	911051	911104	53
815	911158	911211	911264	911317	911371	911424	911477	911530	911584	911637	53
816	911690	911743	911797	911850	911903	911956	912009	912063	912116	912169	53
817	912222	912275	912328	912381	912435	912488	912541	912594	912647	912700	53
818	912753	912806	912859	912913	912966	913019	913072	913125	913178	913231	53
819	913284	913337	913390	913443	913496	913549	913602	913655	913708	913761	53
820	913814	913867	913920	913973	914026	914079	914132	914184	914237	914290	53
821	914343	914396	914449	914502	914555	914608	914660	914713	914766	914819	53
822	914872	914925	914977	915030	915083	915136	915189	915241	915294	915347	53
823	915400	915453	915505	915558	915611	915664	915716	915769	915822	915875	53
824	915927	915980	916033	916085	916138	916191	916243	916296	916349	916401	53
825	916454	916507	916559	916612	916664	916717	916770	916822	916875	916927	53
826	916980	917033	917085	917138	917190	917243	917295	917348	917400	917453	53
827	917506	917558	917611	917663	917716	917768	917820	917873	917925	917978	52
828	918030	918083	918135	918188	918240	918293	918345	918397	918450	918502	52
829	918555	918607	918659	918712	918764	918816	918869	918921	918973	919026	52
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9
52	5	10	16	21	26	31	36	42	47
53	5	11	16	21	26	32	37	42	48
54	5	11	16	22	27	32	38	43	49

D.	1	2	3	4	5	6	7	8	9
55	5	11	16	22	27	33	38	44	49
56	6	11	17	22	28	34	39	45	50

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 8300 to 8849 **Log. 919078 to 946894**

No.	0	1	2	3	4	5	6	7	8	9	D.
830	919078	919130	919183	919235	919287	919340	919392	919444	919496	919549	52
831	919601	919653	919706	919758	919810	919862	919914	919967	920019	920071	52
832	920123	920176	920228	920280	920332	920384	920436	920489	920541	920593	52
833	920645	920697	920749	920801	920853	920906	920958	921010	921062	921114	52
834	921166	921218	921270	921322	921374	921426	921478	921530	921582	921634	52
835	921686	921738	921790	921842	921894	921946	921998	922050	922102	922154	52
836	922206	922258	922310	922362	922414	922466	922518	922570	922622	922674	52
837	922725	922777	922829	922881	922933	922985	923037	923089	923140	923192	52
838	923244	923296	923348	923399	923451	923503	923555	923607	923658	923710	52
839	923702	923814	923865	923917	923969	924021	924072	924124	924176	924228	52
840	924279	924331	924383	924434	924486	924538	924589	924641	924693	924744	52
841	924796	924848	924899	924951	925003	925054	925106	925157	925209	925261	52
842	925312	925364	925415	925467	925518	925570	925621	925673	925725	925776	52
843	925828	925879	925931	925982	926034	926085	926137	926188	926240	926291	51
844	926342	926394	926445	926497	926548	926600	926651	926702	926754	926805	51
845	926857	926908	926959	927011	927062	927114	927165	927216	927268	927319	51
846	927370	927422	927473	927524	927576	927627	927678	927730	927781	927832	51
847	927883	927935	927986	928037	928088	928140	928191	928242	928293	928345	51
848	928396	928447	928498	928549	928601	928652	928703	928754	928805	928857	51
849	928908	928959	929010	929061	929112	929163	929215	929266	929317	929368	51
850	929419	929470	929521	929572	929623	929674	929725	929776	929827	929879	51
851	929930	929981	930032	930083	930134	930185	930236	930287	930338	930389	51
852	930440	930491	930542	930592	930643	930694	930745	930796	930847	930898	51
853	930949	931000	931051	931102	931153	931203	931254	931305	931356	931407	51
854	931458	931509	931560	931610	931661	931712	931763	931814	931865	931915	51
855	931966	932017	932068	932118	932169	932220	932271	932322	932372	932423	51
856	932474	932524	932575	932626	932677	932727	932778	932829	932879	932930	51
857	932981	933031	933082	933133	933183	933234	933285	933335	933386	933437	51
858	933487	933538	933589	933639	933690	933740	933791	933841	933892	933943	51
859	933993	934044	934094	934145	934195	934246	934296	934347	934397	934448	51
860	934498	934549	934599	934650	934700	934751	934801	934852	934902	934953	50
861	935003	935054	935104	935154	935205	935255	935306	935356	935406	935457	50
862	935507	935558	935608	935658	935709	935759	935809	935860	935910	935960	50
863	936011	936061	936111	936162	936212	936262	936313	936363	936413	936463	50
864	936514	936564	936614	936665	936715	936765	936815	936865	936916	936966	50
865	937016	937066	937117	937167	937217	937267	937317	937367	937418	937468	50
866	937518	937568	937618	937668	937718	937769	937819	937869	937919	937969	50
867	938019	938069	938119	938169	938219	938269	938319	938370	938420	938470	50
868	938520	938570	938620	938670	938720	938770	938820	938870	938920	938970	50
869	939020	939070	939120	939170	939220	939270	939320	939369	939419	939469	50
870	939519	939569	939619	939669	939719	939769	939819	939869	939918	939968	50
871	940018	940068	940118	940168	940218	940267	940317	940367	940417	940467	50
872	940516	940566	940616	940666	940716	940765	940815	940865	940915	940964	50
873	941014	941064	941114	941163	941213	941263	941313	941362	941412	941462	50
874	941511	941561	941611	941660	941710	941760	941809	941859	941909	941958	50
875	942008	942058	942107	942157	942207	942256	942306	942355	942405	942455	50
876	942504	942554	942603	942653	942702	942752	942801	942851	942901	942950	50
877	943000	943049	943099	943148	943198	943247	943297	943346	943396	943445	49
878	943495	943544	943593	943643	943692	943742	943791	943841	943890	943939	49
879	943989	944038	944088	944137	944186	944236	944285	944335	944384	944433	49
880	944483	944532	944581	944631	944680	944729	944779	944828	944877	944927	49
881	944976	945025	945074	945124	945173	945222	945272	945321	945370	945419	49
882	945469	945518	945567	945616	945665	945715	945764	945813	945862	945912	49
883	945961	946010	946059	946108	946157	946207	946256	946305	946354	946403	49
884	946452	946501	946551	946600	946649	946698	946747	946796	946845	946894	49
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9
49	5	10	15	20	24	29	34	39	44
50	5	10	15	20	25	30	35	40	45

D.	1	2	3	4	5	6	7	8	9
51	5	10	15	20	25	31	36	41	46
52	5	10	16	21	26	31	36	42	47

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 8850 to 9419 — **Log. 946943 to 974005**

No.	0	1	2	3	4	5	6	7	8	9	D.
885	946943	946992	947041	947090	947140	947189	947238	947287	947336	947385	49
886	947434	947483	947532	947581	947630	947679	947728	947777	947826	947875	49
887	947924	947973	948022	948070	948119	948168	948217	948266	948315	948364	49
888	948413	948462	948511	948560	948609	948657	948706	948755	948804	948853	49
889	948902	948951	948999	949048	949097	949146	949195	949244	949292	949341	49
890	949390	949439	949488	949536	949585	949634	949683	949731	949780	949829	49
891	949878	949926	949975	950024	950073	950121	950170	950219	950267	950316	49
892	950365	950414	950462	950511	950560	950608	950657	950706	950754	950803	49
893	950851	950900	950949	950997	951046	951095	951143	951192	951240	951289	49
894	951338	951386	951435	951483	951532	951580	951629	951677	951726	951775	49
895	951823	951872	951920	951969	952017	952066	952114	952163	952211	952260	48
896	952308	952356	952405	952453	952502	952550	952599	952647	952696	952744	48
897	952792	952841	952889	952938	952986	953034	953083	953131	953180	953228	48
898	953276	953325	953373	953421	953470	953518	953566	953615	953663	953711	48
899	953760	953808	953856	953905	953953	954001	954049	954098	954146	954194	48
900	954243	954291	954339	954387	954435	954484	954532	954580	954628	954677	48
901	954725	954773	954821	954869	954918	954966	955014	955062	955110	955158	48
902	955207	955255	955303	955351	955399	955447	955495	955543	955592	955640	48
903	955688	955736	955784	955832	955880	955928	955976	956024	956072	956120	48
904	956168	956216	956265	956313	956361	956409	956457	956505	956553	956601	48
905	956649	956697	956745	956793	956840	956888	956936	956984	957032	957080	48
906	957128	957176	957224	957272	957320	957368	957416	957464	957512	957559	48
907	957607	957655	957703	957751	957799	957847	957894	957942	957990	958038	48
908	958086	958134	958181	958229	958277	958325	958373	958421	958468	958516	48
909	958564	958612	958659	958707	958755	958803	958850	958898	958946	958994	48
910	959041	959089	959137	959185	959232	959280	959328	959375	959423	959471	48
911	959518	959566	959614	959661	959709	959757	959804	959852	959900	959947	48
912	959995	960042	960090	960138	960185	960233	960280	960328	960376	960423	48
913	960471	960518	960566	960613	960661	960709	960756	960804	960851	960899	48
914	960946	960994	961041	961089	961136	961184	961231	961279	961326	961374	47
915	961421	961469	961516	961563	961611	961658	961706	961753	961801	961848	47
916	961895	961943	961990	962038	962085	962132	962180	962227	962275	962322	47
917	962369	962417	962464	962511	962559	962606	962653	962701	962748	962795	47
918	962843	962890	962937	962985	963032	963079	963126	963174	963221	963268	47
919	963316	963363	963410	963457	963504	963552	963599	963646	963693	963741	47
920	963788	963835	963882	963929	963977	964024	964071	964118	964165	964212	47
921	964260	964307	964354	964401	964448	964495	964542	964590	964637	964684	47
922	964731	964778	964825	964872	964919	964966	965013	965061	965108	965155	47
923	965202	965249	965296	965343	965390	965437	965484	965531	965578	965625	47
924	965672	965719	965766	965813	965860	965907	965954	966001	966048	966095	47
925	966142	566189	966236	966283	966329	966376	966423	966470	966517	966564	47
926	966611	966658	966705	966752	966799	966845	966892	966939	966986	967033	47
927	967080	967127	967173	967220	967267	967314	967361	967408	967454	967501	47
928	967548	967595	967642	967688	967735	967782	967829	967875	967922	967969	47
929	968016	968062	968109	968156	968203	968249	968296	968343	968390	968436	47
930	968483	968530	968576	968623	968670	968716	968763	968810	968856	968903	47
931	968950	968996	969043	969090	969136	969183	969229	969276	969323	969369	47
932	969416	969463	969509	969556	969602	969649	969695	969742	969789	969835	47
933	969882	969928	969975	970021	970068	970114	970161	970207	970254	970300	47
934	970347	970393	970440	970486	970533	970579	970626	970672	970719	970765	46
935	970812	970858	970904	970951	970997	971044	971090	971137	971183	971229	46
936	971276	971322	971369	971415	971461	971508	971554	971601	971647	971693	46
937	971740	971786	971832	971879	971925	971971	972018	972064	972110	972157	46
938	972203	972249	972295	972342	972388	972434	972481	972527	972573	972619	46
939	972666	972712	972758	972804	972851	972897	972943	972989	973035	973082	46
940	973128	973174	973220	973266	973313	973359	973405	973451	973497	973543	46
941	973590	973636	973682	973728	973774	973820	973866	973913	973959	974005	46
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9	D.	1	2	3	4	5	6	7	8	9
46	5	9	14	18	23	28	32	37	41	48	5	10	14	19	24	29	34	38	43
47	5	9	14	19	23	28	33	38	42	49	5	10	15	20	24	29	34	39	44

TABLE XXXV.—(*continued*).

LOGARITHMS OF NUMBERS

No. 9420 to 9999 Log. 974051 to 999957

No.	0	1	2	3	4	5	6	7	8	9	D.
942	974051	974097	974143	974189	974235	974281	974327	974374	974420	974466	46
943	974512	974558	974604	974650	974696	974742	974788	974834	974880	974926	46
944	974972	975018	975064	975110	975156	975202	975248	975294	975340	975386	46
945	975432	975478	975524	975570	975616	975662	975707	975753	975799	975845	46
946	975891	975937	975983	976029	976075	976121	976167	976212	976258	976304	46
947	976350	976396	976442	976488	976533	976579	976625	976671	976717	976763	46
948	976808	976854	976900	976946	976992	977037	977083	977129	977175	977220	46
949	977266	977312	977358	977403	977449	977495	977541	977586	977632	977678	46
950	977724	977769	977815	977861	977906	977952	977998	978043	978089	978135	46
951	978181	978226	978272	978317	978363	978409	978454	978500	978546	978591	46
952	978637	978683	978728	978774	978819	978865	978911	978956	979002	979047	46
953	979093	979138	979184	979230	979275	979321	979366	979412	979457	979503	46
954	979548	979594	979639	979685	979730	979776	979821	979867	979912	979958	46
955	980003	980049	980094	980140	980185	980231	980276	980322	980367	980412	45
956	980458	980503	980549	980594	980640	980685	980730	980776	980821	980867	45
957	980912	980957	981003	981048	981093	981139	981184	981229	981275	981320	45
958	981366	981411	981456	981501	981547	981592	981637	981683	981728	981773	45
959	981819	981864	981909	981954	982000	982045	982090	982135	982181	982226	45
960	982271	982316	982362	982407	982452	982497	982543	982588	982633	982678	45
961	982723	982769	982814	982859	982904	982949	982994	983040	983085	983130	45
962	983175	983220	983265	983310	983356	983401	983446	983491	983536	983581	45
963	983626	983671	983716	983762	983807	983852	983897	983942	983987	984032	45
964	984077	984122	984167	984212	984257	984302	984347	984392	984437	984482	45
965	984527	984572	984617	984662	984707	984752	984797	984842	984887	984932	45
966	984977	985022	985067	985112	985157	985202	985247	985292	985337	985382	45
967	985426	985471	985516	985561	985606	985651	985696	985741	985786	985830	45
968	985875	985920	985965	986010	986055	986100	986144	986189	986234	986279	45
969	986324	986369	986413	986458	986503	986548	986593	986637	986682	986727	45
970	986772	986817	986861	986906	986951	986996	987040	987085	987130	987175	45
971	987219	987264	987309	987353	987398	987443	987488	987532	987577	987622	45
972	987666	987711	987756	987800	987845	987890	987934	987979	988024	988068	45
973	988113	988157	988202	988247	988291	988336	988381	988425	988470	988514	45
974	988559	988604	988648	988693	988737	988782	988826	988871	988916	988960	45
975	989005	989049	989094	989138	989183	989227	989272	989316	989361	989405	45
976	989450	989494	989539	989583	989628	989672	989717	989761	989806	989850	44
977	989895	989939	989983	990028	990072	990117	990161	990206	990250	990294	44
978	990339	990383	990428	990472	990516	990561	990605	990650	990694	990738	44
979	990783	990827	990871	990916	990960	991004	991049	991093	991137	991182	44
980	991226	991270	991315	991359	991403	991448	991492	991536	991580	991625	44
981	991669	991713	991758	991802	991846	991890	991935	991979	992023	992067	44
982	992111	992156	992200	992244	992288	992333	992377	992421	992465	992509	44
983	992554	992598	992642	992686	992730	992774	992819	992863	992907	992951	44
984	992995	993039	993083	993127	993172	993216	993260	993304	993348	993392	44
985	993436	993480	993524	993568	993613	993657	993701	993745	993789	993833	44
986	993877	993921	993965	994009	994053	994097	994141	994185	994229	994273	44
987	994317	994361	994405	994449	994493	994537	994581	994625	994669	994713	44
988	994757	994801	994845	994889	994933	994977	995021	995065	995108	995152	44
989	995196	995240	995284	995328	995372	995416	995460	995504	995547	995591	44
990	995635	995679	995723	995767	995811	995854	995898	995942	995986	996030	44
991	996074	996117	996161	996205	996249	996293	996337	996380	996424	996468	44
992	996512	996555	996599	996643	996687	996731	996774	996818	996862	996907	44
993	996949	996993	997037	997080	997124	997168	997212	997255	997299	997343	44
994	997386	997430	997474	997517	997561	997605	997648	997692	997736	997779	44
995	997823	997867	997910	997954	997998	998041	998085	998129	998172	998216	44
996	998259	998303	998147	998390	998434	998477	998521	998564	998608	998652	44
997	998695	998739	998782	998826	998869	998913	998956	999000	999043	999087	44
998	999131	999174	999218	999261	999305	999348	999392	999435	999479	999522	44
999	999565	999609	999652	999696	999739	999783	999826	999870	999913	999957	43
No.	0	1	2	3	4	5	6	7	8	9	D.

D.	1	2	3	4	5	6	7	8	9	D.	1	2	3	4	5	6	7	8	9
43	4	9	13	17	21	26	30	34	39	45	4	9	13	18	22	27	31	36	40
44	4	9	13	18	22	26	31	35	40	46	5	9	14	18	23	28	32	37	41

TABLE XXXVI.

NATURAL SINES, TANGENTS, SECANTS, ETC.

Deg.	Sine.	Cosec.	Tan.	Cotan.	Secant.	Cosin.	
0	0·00	infinite.	0·00	infinite.	1·00000	1·00000	90
1	0·01745	57·2986	0·01745	57·2899	1·00015	0·99984	89
2	0·03489	28·6537	0·03492	28·6362	1·00060	0·99939	88
3	0·05233	19·1073	0·05240	19·0811	1·00137	0·99862	87
4	0·06975	14·3355	0·06992	14·3006	1·00244	0·99756	86
5	0·08715	11·4737	0·08748	11·4300	1·00381	0·99619	85
6	0·10452	9·5667	0·10510	9·5143	1·00550	0·99452	84
7	0·12186	8·2055	0·12278	8·1443	1·00750	0·99254	83
8	0·13917	7·1852	0·14054	7·1153	1·00982	0·99026	82
9	0·15643	6·3924	0·15838	6·3137	1·01246	0·98768	81
10	0·17364	5·7587	0·17632	5·6712	1·01542	0·98480	80
11	0·19080	5·2408	0·19438	5·1445	1·01871	0·98162	79
12	0·20791	4·8097	0·21255	4·7046	1·02234	0·97814	78
13	0·22495	4·4454	0·23086	4·3314	1·02630	0·97437	77
14	0·24192	4·1335	0·24932	4·0107	1·03061	0·97029	76
15	0·25881	3·8637	0·26794	3·7320	1·03527	0·96592	75
16	0·27563	3·6279	0·28674	3·4874	1·04029	0·96126	74
17	0·29237	3·4203	0·30573	3·2708	1·04569	0·95630	73
18	0·30901	3·2360	0·32491	3·0776	1·05146	0·95105	72
19	0·32556	3·0715	0·34432	2·9042	1·05762	0·94551	71
20	0·34202	2·9238	0·36397	2·7474	1·06417	0·93969	70
21	0·35836	2·7904	0·38386	2·6050	1·07114	0·93358	69
22	0·37460	2·6694	0·40402	2·4750	1·07853	0·92718	68
23	0·39073	2·5593	0·42447	2·3558	1·08636	0·92050	67
24	0·40673	2·4585	0·44522	2·2460	1·09463	0·91354	66
25	0·42261	2·3062	0·46630	2·1445	1·10337	0·90630	65
26	0·43837	2·2811	0·48773	2·0503	1·11260	0·89879	64
27	0·45399	2·2026	0·50952	1·9626	1·12232	0·89100	63
28	0·46947	2·1300	0·53170	1·8807	1·13257	0·88294	62
29	0·48480	2·0626	0·55430	1·8040	1·14335	0·87461	61
30	0·50000	2·0000	0·57735	1·7320	1·15470	0·86602	60
31	0·51503	1·9416	0·60086	1·6642	1·16663	0·85716	59
32	0·52991	1·8870	0·62486	1·6003	1·17917	0·84804	58
33	0·54463	1·8360	0·64940	1·5398	1·19236	0·83867	57
34	0·55919	1·7882	0·67450	1·4825	1·20621	0·82903	56
35	0·57357	1·7434	0·70020	1·4281	1·22077	0·81915	55
36	0·58778	1·7013	0·72654	1·3763	1·23606	0·80901	54
37	0·60181	1·6616	0·75355	1·3270	1·25213	0·79863	53
38	0·61566	1·6242	0·78128	1·2799	1·26901	0·78801	52
39	0·62932	1·5890	0·80978	1·2348	1·28675	0·77714	51
40	0·64278	1·5557	0·83909	1·1917	1·30540	0·76604	50
41	0·65605	1·5242	0·86928	1·1503	1·32501	0·75470	49
42	0·66913	1·4944	0·90040	1·1106	1·34563	0·74314	48
43	0·68199	1·4662	0·93251	1·0723	1·36732	0·73135	47
44	0·69465	1·4395	0·96568	1·0355	1·39016	0·71933	46
45	0·70710	1·4142	1·00000	1·0000	1·41421	0·70710	45
	Cosin.	Secant.	Cotan.	Tan.	Cosec.	Sine.	Deg.

TABLE XXXVII.

LOG. SINES, COSINES, &c.

0h 0m — 0°

′ ″	m. s.	Sine	D.	Cosec.	Tangent	D.	Cotang.	Secant	D.	Cosine	m. s.	′ ″
0	0	— ∞		∞	— ∞		∞	10·000000	0	10·000000	60	60
30	2	6·162696	477121	13·837304	6·162696	477121	13·837304	10·000000	0	10·000000	58	30
1	4	6·463726	221849	13·536274	6·463726	221849	13·536274	10·000000	0	10·000000	56	59
30	6	6·639817	146128	13·360183	6·639817	146128	13·360183	10·000000	0	10·000000	54	30
2	8	6·764756	109145	13·235244	6·764756	109145	13·235244	10·000000	0	10·000000	52	58
30	10	6·861666	87150	13·138334	6·861666	87150	13·138334	10·000000	0	10·000000	50	30
3	12	6·940847	72550	13·059153	6·940847	72551	13·059153	10·000000	0	10·000000	48	57
30	14	7·007794	62148	12·992206	7·007794	62148	12·992206	10·000000	0	10·000000	46	30
4	16	7·065786	54358	12·934214	7·065786	54357	12·934214	10·000000	0	10·000000	44	56
30	18	7·116939	48305	12·883061	7·116939	48305	12·883061	10·000000	0	10·000000	42	30
5	20	7·162696	43465	12·837304	7·162696	43466	12·837304	10·000000	0	10·000000	40	55
30	22	7·204089	39509	12·795911	7·204089	39508	12·795911	10·000001	0	10·999999	38	30
6	24	7·241877	36212	12·758123	7·241878	36213	12·758122	10·000001	0	9·999999	36	54
30	26	7·276639	33424	12·723361	7·276640	33423	12·723360	10·000001	0	9·999999	34	30
7	28	7·308824	31034	12·691176	7·308825	31035	12·691175	10·000001	0	9·999999	32	53
30	30	7·338787	28963	12·661213	7·338788	28964	12·661212	10·000001	0	9·999999	30	30
8	32	7·366816	27153	12·633184	7·366817	27152	12·633183	10·000001	0	9·999999	28	52
30	34	7·393145	25554	12·606855	7·393146	25554	12·606854	10·000001	0	9·999999	26	30
9	36	7·417968	24133	12·582032	7·417970	24134	12·582030	10·000001	0	9·999999	24	51
30	38	7·441449	22863	12·558551	7·441451	22863	12·558549	10·000002	0	9·999998	22	30
10	40	7·463726	21719	12·536274	7·463727	21719	12·536273	10·000002	0	9·999998	20	50
30	42	7·484915	20685	12·515085	7·484917	20685	12·515083	10·000002	0	9·999998	18	30
11	44	7·505118	19744	12·494882	7·505120	19744	12·494880	10·000002	0	9·999998	16	49
30	46	7·524423	18885	12·475577	7·524426	18886	12·475574	10·000002	0	9·999998	14	30
12	48	7·542906	18098	12·457094	7·542909	18098	12·457091	10·000003	0	9·999997	12	48
30	50	7·560635	17374	12·439365	7·560638	17374	12·439362	10·000003	0	9·999997	10	30
13	52	7·577668	16706	12·422332	7·577672	16706	12·422328	10·000003	0	9·999997	8	47
30	54	7·594059	16087	12·405941	7·594062	16087	12·405938	10·000003	0	9·999997	6	30
14	56	7·609853	15512	12·390147	7·609857	15512	12·390143	10·000004	0	9·999996	4	46
30	58	7·625093	14977	12·374907	7·625097	14978	12·374903	10·000004	0	9·999996	2	30
15	1	7·639816	14478	12·360184	7·639820	14478	12·360180	10·000004	0	9·999996	59	45
30	2	7·654056	14010	12·345944	7·654061	14011	12·345939	10·000004	0	9·999996	58	30
16	4	7·667845	13573	12·332155	7·667849	13573	12·332151	10·000005	0	9·999995	56	44
30	6	7·681208	13161	12·318792	7·681213	13161	12·318787	10·000005	0	9·999995	54	30
17	8	7·694173	12774	12·305827	7·694179	12775	12·305821	10·000005	0	9·999995	52	43
30	10	7·706762	12410	12·293238	7·706768	12409	12·293232	10·000006	0	9·999994	50	30
18	12	7·718997	12064	12·281003	7·719003	12065	12·280997	10·000006	0	9·999994	48	42
30	14	7·730896	11738	12·269104	7·730902	11739	12·269098	10·000006	0	9·999994	46	30
19	16	7·742478	11430	12·257522	7·742484	11429	12·257516	10·000007	0	9·999993	44	41
30	18	7·753758	11136	12·246242	7·753765	11137	12·246235	10·000007	0	9·999993	42	30
20	20	7·764754	10858	12·235246	7·764761	10858	12·235239	10·000007	0	9·999993	40	40
30	22	7·775477	10593	12·224523	7·775485	10593	12·224515	10·000008	0	9·999992	38	30
21	24	7·785943	10340	12·214057	7·785951	10342	12·214049	10·000008	0	9·999992	36	39
30	26	7·796162	10100	12·203838	7·796170	10100	12·203830	10·000009	0	9·999991	34	30
22	28	7·806146	9871	12·193854	7·806155	9871	12·193845	10·000009	0	9·999991	32	38
30	30	7·815906	9651	12·184094	7·815915	9652	12·184085	10·000009	0	9·999991	30	30
23	32	7·825451	9442	12·174549	7·825460	9442	12·174540	10·000010	0	9·999990	28	37
30	34	7·834791	9240	12·165209	7·834801	9241	12·165199	10·000010	0	9·999990	26	30
24	36	7·843934	9048	12·156066	7·843944	9048	12·156056	10·000011	0	9·999989	24	36
30	38	7·852889	8864	12·147111	7·852900	8864	12·147100	10·000011	0	9·999989	22	30
25	40	7·861662	8686	12·138338	7·861674	8686	12·138326	10·000011	0	9·999989	20	35
30	42	7·870262	8515	12·129738	7·870274	8516	12·129726	10·000012	0	9·999988	18	30
26	44	7·878695	8352	12·121305	7·878708	8353	12·121292	10·000012	0	9·999988	16	34
30	46	7·886963	8195	12·113032	7·886981	8195	12·113019	10·000013	0	9·999987	14	30
27	48	7·895085	8042	12·104915	7·895099	8043	12·104901	10·000013	0	9·999987	12	33
30	50	7·903054	7896	12·096946	7·903068	7897	12·096932	10·000014	0	9·999986	10	30
28	52	7·910879	7756	12·089121	7·910894	7755	12·089106	10·000014	1	9·999986	8	32
30	54	7·918566	7619	12·081434	7·918581	7620	12·081419	10·000015	1	9·999985	6	30
29	56	7·926119	7488	12·073881	7·926134	7488	12·073866	10·000015	1	9·999985	4	31
30	58	7·933543	7361	12·066457	7·933559	7362	12·066441	10·000016	1	9·999984	2	30
30	2	7·940842	7238	12·059158	7·940858	7239	12·059142	10·000017	1	9·999983	58	30
′ ″	m. s.	Cosine	D.	Secant	Cotang.	D.	Tangent	Cosec.	D.	Sine	m. s.	′ ″

89° — 5h 58m

TABLE XXXVII.—(*continued*).

LOG. SINES. COSINES. &c.

0ʰ 2ᵐ — 0°

′ ″	m. s.	Sine	D.	Cosec.	Tangent	D.	Cotang.	Secant	D.	Cosine	m. s.	′ ″
30	0	7·940842	7238	12·059158	7·940858	7239	12·059142	10·000017		9·999983	58	30
30	2	7·948020	7119	12·051980	7·948037	7120	12·051963	10·000017	1	9·999983	58	30
31	4	7·955082	7005	12·044918	7·955100	7005	12·044900	10·000018	1	9·999982	56	29
30	6	7·962031	6894	12·037969	7·962049	6894	12·037951	10·000018	1	9·999982	54	30
32	8	7·968870	6785	12·031130	7·968889	6787	12·031111	10·000019	1	9·999981	52	28
30	10	7·975603	6682	12·024397	7·975622	6682	12·024378	10·000019	1	9·999981	50	30
33	12	7·982233	6580	12·017767	7·982253	6580	12·017747	10·000020	1	9·999980	48	27
30	14	7·988764	6482	12·011236	7·988785	6483	12·011215	10·000021	1	9·999979	46	30
34	16	7·995198	6387	12·004802	7·995219	6387	12·004781	10·000021	1	9·999979	44	26
30	18	8·001538	6294	11·998462	8·001560	6295	11·998440	10·000022	1	9·999978	42	30
35	20	8·007787	6204	11·992213	8·007809	6204	11·992191	10·000023	1	9·999977	40	25
30	22	8·013947	6116	11·986053	8·013970	6118	11·986030	10·000023	1	9·999977	38	30
36	24	8·020021	6032	11·979979	8·020045	6032	11·979956	10·000024	1	9·999976	36	24
30	26	8·026011	5949	11·973989	8·026035	5950	11·973965	10·000024	1	9·999976	34	30
37	28	8·031919	5869	11·968081	8·031945	5869	11·968055	10·000025	1	9·999975	32	23
30	30	8·037749	5790	11·962251	8·037775	5792	11·962225	10·000026	1	9·999974	30	30
38	32	8·043501	5715	11·956499	8·043527	5714	11·956473	10·000027	1	9·999973	28	22
30	34	8·049178	5640	11·950822	8·049205	5641	11·950795	10·000027	1	9·999973	26	30
39	36	8·054781	5567	11·945219	8·054809	5569	11·945191	10·000028	1	9·999972	24	21
30	38	8·060314	5498	11·939686	8·060342	5498	11·939658	10·000029	1	9·999971	22	30
40	40	8·065776	5428	11·934224	8·065806	5429	11·934194	10·000029	1	9·999971	20	20
30	42	8·071171	5362	11·928829	8·071201	5362	11·928-99	10·000030	1	9·999970	18	30
41	44	8·076500	5296	11·923500	8·076531	5297	11·923469	10·000031	1	9·999969	16	19
30	46	8·081764	5232	11·918236	8·081795	5233	11·918205	10·000032	1	9·999968	14	30
42	48	8·086965	5170	11·913035	8·086997	5171	11·913003	10·000032	1	9·999968	12	18
30	50	8·092104	5109	11·907896	8·092137	5110	11·907863	10·000033	1	9·999967	10	30
43	52	8·097183	5050	11·902817	8·097217	5050	11·902783	10·000034	1	9·999966	8	17
30	54	8·102204	4991	11·897796	8·102239	4993	11·897761	10·000035	1	9·999965	6	30
44	56	8·107167	4935	11·892833	8·107203	4935	11·892797	10·000036	1	9·999964	4	16
30	58	8·112074	4880	11·887926	8·112110	4881	11·887890	10·000036	1	9·999964	2	30
45	3	8·116926	4825	11·883074	8·116963	4826	11·883037	10·000037	1	9·999963	57	15
30	2	8·121725	4772	11·878275	8·121763	4773	11·878237	10·000038	1	9·999962	58	30
46	4	8·126471	4721	11·873529	8·126510	4721	11·873490	10·000039	1	9·999961	56	14
30	6	8·131166	4669	11·868834	8·131206	4671	11·868794	10·000040	1	9·999960	54	30
47	8	8·135810	4620	11·864190	8·135851	4620	11·864149	10·000041	1	9·999959	52	13
30	10	8·140406	4572	11·859594	8·140447	4572	11·859553	10·000041	1	9·999959	50	30
48	12	8·144953	4523	11·855047	8·144996	4525	11·855004	10·000042	1	9·999958	48	12
30	14	8·149453	4477	11·850547	8·149497	4478	11·850503	10·000043	1	9·999957	46	30
49	16	8·153907	4431	11·846093	8·153952	4432	11·846048	10·000044	1	9·999956	44	11
30	18	8·158316	4387	11·841684	8·158361	4388	11·841639	10·000045	1	9·999955	42	30
50	20	8·162681	4343	11·837319	8·162727	4343	11·837273	10·000046	1	9·999954	40	10
30	22	8·167002	4299	11·832998	8·167049	4301	11·832951	10·000047	1	9·999953	38	30
51	24	8·171280	4258	11·828720	8·171328	4258	11·828672	10·000048	1	9·999952	36	9
30	26	8·175517	4216	11·824483	8·175566	4217	11·824434	10·000049	1	9·999951	34	30
52	28	8·179713	4176	11·820287	8·179763	4177	11·820237	10·000050	1	9·999950	32	8
30	30	8·183869	4136	11·816131	8·183919	4137	11·816081	10·000051	1	9·999949	30	30
53	32	8·187985	4096	11·812015	8·188036	4097	11·811964	10·000052	1	9·999948	28	7
30	34	8·192062	4059	11·807938	8·192115	4060	11·807885	10·000053	1	9·999947	26	30
54	36	8·196102	4021	11·803898	8·196156	4022	11·803844	10·000054	1	9·999946	24	6
30	38	8·200104	3984	11·799896	8·200159	3985	11·799841	10·000055	1	9·999945	22	30
55	40	8·204070	3948	11·795930	8·204126	3949	11·795874	10·000056	1	9·999944	20	5
30	42	8·208000	3912	11·792000	8·208057	3913	11·791943	10·000057	1	9·999943	18	30
56	44	8·211895	3877	11·788105	8·211953	3878	11·788047	10·000058	1	9·999942	16	4
30	46	8·215755	3843	11·784245	8·215814	3844	11·784186	10·000059	1	9·999941	14	30
57	48	8·219581	3810	11·780419	8·219641	3811	11·780359	10·000060	1	9·999940	12	3
30	50	8·223374	3776	11·776626	8·223434	3777	11·776566	10·000061	1	9·999939	10	30
58	52	8·227134	3743	11·772866	8·227195	3745	11·772805	10·000062	1	9·999938	8	2
30	54	8·230861	3712	11·769139	8·230924	3712	11·769076	10·000063	1	9·999937	6	30
59	56	8·234557	3680	11·765443	8·234621	3681	11·765379	10·000064	1	9·999936	4	1
30	58	8·238221	3649	11·761779	8·238286	3651	11·761714	10·000065	1	9·999935	2	30
60	4	8·241855	3619	11·758145	8·241921	3620	11·758079	10·000066	1	9·999934	0	0
′ ″	m. s.	Cosine	D.	Secant	Cotang.	D.	Tangent	Cosec.	D.	Sine	m. s.	′ ″

89° — 5ʰ 56ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 4m — 1°

′ ″	m. s.	Sine.	D.	Cosec.	Tangent	D.	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	8·241855	3619	11·758145	8·241921	3620	11·758079	10·000066		9·999934	56	60
30	2	8·245459	3589	11·754541	8·245526	3590	11·754474	10·000067	1″ 0	9·999933	58	30
1	4	8·249033	3559	11·750967	8·249102	3560	11·750898	10·000068	2 0	9·999932	56	59
30	6	8·252578	3531	11·747422	8·252648	3532	11·747352	10·000069	3 0	9·999931	54	30
2	8	8·256094	3502	11·743906	8·256165	3503	11·743835	10·000071	4 0	9·999929	52	58
30	10	8·259582	3474	11·740418	8·259654	3475	11·740346	10·000072	5 0	9·999928	50	30
3	12	8·263042	3446	11·736958	8·263115	3448	11·736885	10·000073	6 0	9·999927	48	57
30	14	8·266475	3419	11·733525	8·266549	3420	11·733451	10·000074	7 0	9·999926	46	30
4	16	8·269881	3393	11·730119	8·269956	3394	11·730044	10·000075	8 0	9·999925	44	56
30	18	8·273260	3366	11·726740	8·273337	3367	11·726663	10·000076	9 0	9·999924	42	30
5	20	8·276614	3341	11·723386	8·276691	3342	11·723309	10·000078	10 0	9·999922	40	55
30	22	8·279941	3314	11·720059	8·280020	3316	11·719980	10·000079	11 0	9·999921	38	30
6	24	8·283243	3290	11·716757	8·283323	3291	11·716677	10·000080	12 0	9·999920	36	54
30	26	8·286521	3265	11·713479	8·286602	3266	11·713398	10·000081	13 1	9·999919	34	30
7	28	8·289773	3241	11·710227	8·289856	3242	11·710144	10·000082	14 1	9·999918	32	53
30	30	8·293002	3216	11·706998	8·293086	3218	11·706914	10·000084	15 1	9·999916	30	30
8	32	8·296207	3193	11·703793	8·296292	3194	11·703708	10·000085	16 1	9·999915	28	52
30	34	8·299388	3170	11·700612	8·299474	3171	11·700526	10·000086	17 1	9·999914	26	30
9	36	8·302546	3147	11·697454	8·302634	3148	11·697366	10·000087	18 1	9·999913	24	51
30	38	8·305681	3124	11·694319	8·305770	3125	11·694230	10·000089	19 1	9·999911	22	30
10	40	8·308794	3102	11·691206	8·308884	3103	11·691116	10·000090	20 1	9·999910	20	50
30	42	8·311885	3080	11·688115	8·311976	3081	11·688024	10·000091	21 1	9·999909	18	30
11	44	8·314954	3058	11·685046	8·315046	3059	11·684954	10·000093	22 1	9·999907	16	49
30	46	8·318001	3036	11·681999	8·318095	3038	11·681905	10·000094	23 1	9·999906	14	30
12	48	8·321027	3016	11·678973	8·321122	3017	11·678878	10·000095	24 1	9·999905	12	48
30	50	8·324032	2995	11·675968	8·324129	2996	11·675871	10·000097	25 1	9·999903	10	30
13	52	8·327016	2974	11·672984	8·327114	2975	11·672886	10·000098	26 1	9·999902	8	47
30	54	8·329980	2954	11·670020	8·330080	2956	11·669920	10·000099	27 1	9·999901	6	30
14	56	8·332924	2934	11·667076	8·333025	2935	11·666975	10·000101	28 1	9·999899	4	46
30	58	8·335848	2914	11·664152	8·335950	2916	11·664050	10·000102	29 1	9·999898	2	30
15	5	8·338753	2895	11·661247	8·338856	2896	11·661144	10·000103	30 1	9·999897	55	45
30	2	8·341638	2876	11·658362	8·341743	2877	11·658257	10·000105	1 0	9·999895	58	30
16	4	8·344504	2856	11·655496	8·344610	2858	11·655390	10·000106	2 0	9·999894	56	44
30	6	8·347352	2838	11·652648	8·347459	2840	11·652541	10·000108	3 0	9·999892	54	30
17	8	8·350181	2820	11·649819	8·350289	2821	11·649711	10·000109	4 0	9·999891	52	43
30	10	8·352991	2801	11·647009	8·353101	2803	11·646899	10·000110	5 0	9·999890	50	30
18	12	8·355783	2784	11·644217	8·355895	2784	11·644105	10·000112	6 0	9·999888	48	42
30	14	8·358558	2766	11·641442	8·358671	2768	11·641329	10·000113	7 0	9·999887	46	30
19	16	8·361315	2748	11·638685	8·361430	2749	11·638570	10·000115	8 0	9·999885	44	41
30	18	8·364055	2731	11·635945	8·364171	2733	11·635829	10·000116	9 0	9·999884	42	30
20	20	8·366777	2714	11·633223	8·366895	2715	11·633105	10·000118	10 1	9·999882	40	40
30	22	8·369482	2697	11·630518	8·369601	2699	11·630399	10·000119	11 1	9·999881	38	30
21	24	8·372171	2680	11·627829	8·372292	2681	11·627708	10·000121	12 1	9·999879	36	39
30	26	8·374843	2664	11·625157	8·374965	2666	11·625035	10·000122	13 1	9·999878	34	30
22	28	8·377499	2648	11·622501	8·377622	2649	11·622378	10·000124	14 1	9·999876	32	38
30	30	8·380138	2631	11·619862	8·380263	2633	11·619737	10·000125	15 1	9·999875	30	30
23	32	8·382762	2616	11·617238	8·382889	2617	11·617111	10·000127	16 1	9·999873	28	37
30	34	8·385370	2600	11·614630	8·385498	2602	11·614502	10·000128	17 1	9·999872	26	30
24	36	8·387962	2585	11·612038	8·388092	2586	11·611908	10·000130	18 1	9·999870	24	36
30	38	8·390539	2569	11·609461	8·390670	2571	11·609330	10·000131	19 1	9·999869	22	30
25	40	8·393101	2554	11·606899	8·393234	2556	11·606766	10·000133	20 1	9·999867	20	35
30	42	8·395647	2539	11·604352	8·395782	2540	11·604218	10·000134	21 1	9·999866	18	30
26	44	8·398179	2525	11·601821	8·398315	2526	11·601685	10·000136	22 1	9·999864	16	34
30	46	8·400696	2510	11·599304	8·400834	2512	11·599166	10·000137	23 1	9·999863	14	30
27	48	8·403199	2495	11·596801	8·403338	2497	11·596662	10·000139	24 1	9·999861	12	33
30	50	8·405687	2481	11·594313	8·405828	2483	11·594172	10·000141	25 1	9·999859	10	30
28	52	8·408161	2467	11·591839	8·408304	2468	11·591696	10·000142	26 1	9·999858	8	32
30	54	8·410621	2453	11·589379	8·410765	2455	11·589235	10·000144	27 1	9·999856	6	30
29	56	8·413068	2440	11·586932	8·413213	2441	11·586787	10·000146	28 1	9·999854	4	31
30	58	8·415500	2425	11·584500	8·415647	2427	11·584353	10·000147	29 1	9·999853	2	30
30	6	8·417919	2412	11·582081	8·418068	2414	11·581932	10·000149	30 2	9·999851	0	30
′ ″	m. s.	Cosine	D.	Secant	Cotang.	D.	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

88° — 5h 54m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 6m — 1°

′ ″	m. s.	Sine	D.	Cosec.	Tangent	D.	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	8·417919	2412	11·582081	8·418068	2414	11·581932	10·000149		9·999851	54	30
30	2	8·420325	2399	11·579675	8·420475	2401	11·579525	10·000151	1″ 0	9·999849	58	30
31	4	8·422717	2386	11·577283	8·422869	2387	11·577131	10·000152	2 0	9·999848	56	29
30	6	8·425096	2373	11·574904	8·425250	2374	11·574750	10·000154	3 0	9·999846	54	30
32	8	8·427462	2359	11·572538	8·427618	2362	11·572382	10·000156	4 0	9·999844	52	28
30	10	8·429815	2347	11·570185	8·429973	2348	11·570027	10·000157	5 0	9·999843	50	30
33	12	8·432156	2335	11·567844	8·432315	2336	11·567685	10·000159	6 0	9·999841	48	27
30	14	8·434484	2322	11·565516	8·434645	2324	11·565355	10·000161	7 0	9·999839	46	30
34	16	8·436800	2309	11·563200	8·436962	2311	11·563038	10·000162	8 0	9·999838		26
30	18	8·439103	2297	11·560897	8·439267	2299	11·560733	10·000164	9 0	9·999836	42	30
35	20	8·441394	2286	11·558606	8·441560	2287	11·558440	10·000166	10 1	9·999834	40	25
30	22	8·443674	2273	11·556326	8·443841	2275	11·556159	10·000168	11 1	9·999832	38	30
36	24	8·445941	2261	11·554059	8·446110	2263	11·553890	10·000169	12 1	9·999831	36	24
30	26	8·448196	2250	11·551804	8·448368	2252	11·551632	10·000171	13 1	9·999829	34	30
37	28	8·450440	2238	11·549560	8·450613	2240	11·549387	10·000173	14 1	9·999827	32	23
30	30	8·452673	2226	11·547327	8·452847	2228	11·547153	10·000175	15 1	9·999825	30	30
38	32	8·454893	2216	11·545107	8·455070	2217	11·544930	10·000176	16 1	9·999824	28	22
30	34	8·457103	2203	11·542897	8·457281	2206	11·542719	10·000178	17 1	9·999822	26	30
39	36	8·459301	2193	11·540699	8·459481	2194	11·540519	10·000180	18 1	9·999820	24	21
30	38	8·461489	2182	11·538511	8·461670	2184	11·538330	10·000182	19 1	9·999818	22	30
40	40	8·463665	2171	11·536335	8·463849	2173	11·536151	10·000184	20 1	9·999816	20	20
30	42	8·465830	2160	11·534170	8·466016	2162	11·533984	10·000186	21 1	9·999814	18	30
41	44	8·467985	2149	11·532015	8·468172	2151	11·531828	10·000187	22 1	9·999813	16	19
30	46	8·470129	2139	11·529871	8·470318	2140	11·529682	10·000189	23 1	9·999811	14	30
42	48	8·472263	2128	11·527737	8·472454	2131	11·527546	10·000191	24 1	9·999809	12	18
30	50	8·474386	2118	11·525614	8·474579	2119	11·525421	10·000193	25 2	9·999807	10	30
43	52	8·476498	2108	11·523502	8·476693	2110	11·523307	10·000195	26 2	9·999805	8	17
30	54	8·478601	2097	11·521399	8·478798	2099	11·521202	10·000197	27 2	9·999803	6	30
44	56	8·480693	2088	11·519307	8·480892	2089	11·519108	10·000199	28 2	9·999801	4	16
30	58	8·482776	2077	11·517224	8·482976	2080	11·517024	10·000201	29 2	9·999799	2	30
45	7	8·484848	2067	11·515152	8·485050	2069	11·514950	10·000203	30 2	9·999797	53	15
30	2	8·486910	2058	11·513090	8·487115	2060	11·512885	10·000205	1 0	9·999795	58	30
46	4	8·488963	2048	11·511037	8·489170	2049	11·510830	10·000206	2 0	9·999794	56	14
30	6	8·491006	2038	11·508994	8·491215	2041	11·508785	10·000208	3 0	9·999792	54	30
47	8	8·493040	2029	11·506960	8·493250	2030	11·506750	10·000210	4 0	9·999790	52	13
30	10	8·495064	2019	11·504936	8·495276	2022	11·504724	10·000212	5 0	9·999788	50	30
48	12	8·497078	2010	11·502922	8·497293	2012	11·502707	10·000214	6 0	9·999786	48	12
30	14	8·499084	2001	11·500916	8·499300	2002	11·500700	10·000216	7 0	9·999784	46	30
49	16	8·501080	1991	11·498920	8·501298	1994	11·498702	10·000218	8 1	9·999782	44	11
30	18	8·503067	1983	11·496933	8·503287	1984	11·496713	10·000220	9 1	9·999780	42	30
50	20	8·505045	1973	11·494955	8·505267	1976	11·494733	10·000222	10 1	9·999778	40	10
30	22	8·507014	1965	11·492986	8·507238	1966	11·492762	10·000224	11 1	9·999776	38	30
51	24	8·508974	1955	11·491026	8·509200	1958	11·490800	10·000226	12 1	9·999774	36	9
30	26	8·510925	1947	11·489075	8·511153	1949	11·488847	10·000228	13 1	9·999772	34	30
52	28	8·512867	1938	11·487133	8·513098	1940	11·486902	10·000231	14 1	9·999769	32	8
30	30	8·514801	1930	11·485199	8·515034	1931	11·484966	10·000233	15 1	9·999767	30	30
53	32	8·516726	1921	11·483274	8·516961	1923	11·483039	10·000235	16 1	9·999765	28	7
30	34	8·518643	1912	11·481357	8·518880	1915	11·481120	10·000237	17 1	9·999763	26	30
54	36	8·520551	1904	11·479449	8·520790	1906	11·479210	10·000239	18 1	9·999761	24	6
30	38	8·522451	1896	11·477549	8·522692	1898	11·477308	10·000241	19 1	9·999759	22	30
55	40	8·524343	1888	11·475657	8·524586	1890	11·475414	10·000243	20 1	9·999757	20	5
30	42	8·526226	1879	11·473774	8·526472	1881	11·473528	10·000245	21 1	9·999755	18	30
56	44	8·528102	1871	11·471898	8·528349	1874	11·471651	10·000247	22 2	9·999753	16	4
30	46	8·529969	1864	11·470031	8·530218	1865	11·469782	10·000249	23 2	9·999751	14	30
57	48	8·531828	1855	11·468172	8·532080	1857	11·467920	10·000252	24 2	9·999748	12	3
30	50	8·533679	1847	11·466321	8·533933	1850	11·466067	10·000254	25 2	9·999746	10	30
58	52	8·535523	1840	11·464477	8·535779	1842	11·464221	10·000256	26 2	9·999744	8	2
30	54	8·537358	1831	11·462642	8·537617	1834	11·462383	10·000258	27 2	9·999742	6	30
59	56	8·539186	1824	11·460814	8·539447	1826	11·460553	10·000260	28 2	9·999740	4	1
30	58	8·541007	1817	11·458993	8·541269	1818	11·458731	10·000262	29 2	9·999738	2	30
60	8	8·542819	1809	11·457181	8·543084	1811	11·456916	10·000265	30 2	9·999735	0	0
′ ″	m. s.	Cosine	D.	Secant	Cotang.	D.	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

88° — 5h 52m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 8m — 2°

′ ″	m. s.	Sine	D.	Cosec.	Tangent	D.	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	8·542819	1809	11·457181	8·543084	1811	11·456716	10·000265		9·999735	52	60
30	2	8·544624	1801	11·455376	8·544891	1804	11·455109	10·000267	1″ 0	9·999733	58	30
1	4	8·546422	1794	11·453578	8·546691	1796	11·453309	10·000269	2 0	9·999731	56	59
30	6	8·548212	1786	11·451788	8·548483	1789	11·451517	10·000271	3 0	9·999729	54	30
2	8	8·549995	1779	11·450005	8·550268	1781	11·449732	10·000274	4 0	9·999726	52	58
30	10	8·551770	1772	11·448230	8·552046	1774	11·447954	10·000276	5 0	9·999724	50	30
3	12	8·553539	1765	11·446461	8·553817	1767	11·446183	10·000278	6 0	9·999722	48	57
30	14	8·555300	1758	11·444700	8·555580	1760	11·444420	10·000280	7 1	9·999720	46	30
4	16	8·557054	1750	11·442946	8·557336	1753	11·442664	10·000283	8 1	9·999717	44	56
30	18	8·558801	1743	11·441199	8·559085	1745	11·440915	10·000285	9 1	9·999715	42	30
5	20	8·560540	1737	11·439460	8·560828	1739	11·439172	10·000287	10 1	9·999713	40	55
30	22	8·562273	1729	11·437727	8·562563	1732	11·437437	10·000289	11 1	9·999711	38	30
6	24	8·563999	1723	11·436001	8·564291	1725	11·435709	10·000292	12 1	9·999708	36	54
30	26	8·565719	1716	11·434281	8·566013	1718	11·433987	10·000294	13 1	9·999706	34	30
7	28	8·567431	1709	11·432569	8·567727	1711	11·432273	10·000296	14 1	9·999704	32	53
30	30	8·569137	1702	11·430863	8·569435	1705	11·430565	10·000299	15 1	9·999701	30	30
8	32	8·570836	1696	11·429164	8·571137	1698	11·428863	10·000301	16 1	9·999699	28	52
30	34	8·572528	1689	11·427472	8·572832	1692	11·427168	10·000304	17 1	9·999696	26	30
9	36	8·574214	1682	11·425786	8·574520	1684	11·425480	10·000306	18 1	9·999694	24	51
30	38	8·575893	1676	11·424107	8·576201	1679	11·423799	10·000308	19 1	9·999692	22	30
10	40	8·577566	1670	11·422434	8·577877	1672	11·422123	10·000311	20 2	9·999689	20	50
30	42	8·579232	1663	11·420768	8·579545	1665	11·420455	10·000313	21 2	9·999687	18	30
11	44	8·580892	1657	11·419108	8·581208	1660	11·418792	10·000315	22 2	9·999685	16	49
30	46	8·582546	1650	11·417454	8·582864	1652	11·417136	10·000318	23 2	9·999682	14	30
12	48	8·584193	1645	11·415807	8·584514	1647	11·415486	10·000320	24 2	9·999680	12	48
30	50	8·585834	1638	11·414166	8·586157	1641	11·413843	10·000323	25 2	9·999677	10	30
13	52	8·587469	1632	11·412531	8·587795	1634	11·412205	10·000325	26 2	9·999675	8	47
30	54	8·589098	1625	11·410902	8·589426	1628	11·410574	10·000328	27 2	9·999672	6	30
14	56	8·590721	1620	11·409279	8·591051	1622	11·408949	10·000330	28 2	9·999670	4	46
30	58	8·592338	1614	11·407662	8·592670	1616	11·407330	10·000332	29 2	9·999668	2	30
15	9	8·593948	1607	11·406052	8·594283	1611	11·405717	10·000335	30 2	9·999665	51	45
30	2	8·595553	1602	11·404447	8·595890	1604	11·404110	10·000337	1 0	9·999663	58	30
16	4	8·597152	1596	11·402848	8·597492	1598	11·402508	10·000340	2 0	9·999660	56	44
30	6	8·598745	1590	11·401255	8·599087	1593	11·400913	10·000342	3 0	9·999658	54	30
17	8	8·600332	1584	11·399668	8·600677	1586	11·399323	10·000345	4 0	9·999655	52	43
30	10	8·601913	1579	11·398087	8·602260	1581	11·397740	10·000347	5 0	9·999653	50	30
18	12	8·603489	1572	11·396511	8·603839	1576	11·396161	10·000350	6 1	9·999650	48	42
30	14	8·605058	1567	11·394942	8·605411	1569	11·394589	10·000353	7 1	9·999647	46	30
19	16	8·606623	1562	11·393377	8·606978	1564	11·393022	10·000355	8 1	9·999645	44	41
30	18	8·608181	1555	11·391819	8·608539	1558	11·391461	10·000358	9 1	9·999642	42	30
20	20	8·609734	1551	11·390266	8·610094	1553	11·389906	10·000360	10 1	9·999640	40	40
30	22	8·611282	1544	11·388718	8·611644	1547	11·388356	10·000363	11 1	9·999637	38	30
21	24	8·612823	1539	11·387177	8·613189	1542	11·386811	10·000365	12 1	9·999635	36	39
30	26	8·614360	1534	11·385640	8·614728	1536	11·385272	10·000368	13 1	9·999632	34	30
22	28	8·615891	1529	11·384109	8·616262	1531	11·383738	10·000371	14 1	9·999629	32	38
30	30	8·617417	1522	11·382583	8·617790	1526	11·382210	10·000373	15 1	9·999627	30	30
23	32	8·618937	1518	11·381063	8·619313	1520	11·380687	10·000376	16 1	9·999624	28	37
30	34	8·620452	1512	11·379548	8·620830	1515	11·379170	10·000378	17 2	9·999622	26	30
24	36	8·621962	1508	11·378038	8·622343	1510	11·377657	10·000381	18 2	9·999619	24	36
30	38	8·623466	1501	11·376534	8·623850	1505	11·376150	10·000384	19 2	9·999616	22	30
25	40	8·624965	1497	11·375035	8·625352	1499	11·374648	10·000386	20 2	9·999614	20	35
30	42	8·626459	1492	11·373541	8·626849	1494	11·373151	10·000389	21 2	9·999611	18	30
26	44	8·627948	1486	11·372052	8·628340	1489	11·371660	10·000392	22 2	9·999608	16	34
30	46	8·629432	1481	11·370568	8·629827	1484	11·370173	10·000394	23 2	9·999606	14	30
27	48	8·630911	1477	11·369089	8·631308	1479	11·368692	10·000397	24 2	9·999603	12	33
30	50	8·632385	1471	11·367615	8·632785	1474	11·367215	10·000400	25 2	9·999600	10	30
28	52	8·633854	1466	11·366146	8·634256	1469	11·365744	10·000403	26 2	9·999597	8	32
30	54	8·635317	1462	11·364683	8·635723	1464	11·364277	10·000405	27 2	9·999595	6	30
29	56	8·636776	1456	11·363224	8·637184	1459	11·362816	10·000408	28 3	9·999592	4	31
30	58	8·638230	1452	11·361770	8·638641	1455	11·361359	10·000411	29 3	9·999589	2	30
30	10	8·639680	1446	11·360320	8·640093	1449	11·359907	10·000414	30 3	9·999586	0	30
′ ″	m. s.	Cosine	D.	Secant	Cotang.	D.	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

87° — 5h 50m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 10m — 2°

′ ″	m. s.	Sine	D.	Cosec.	Tangent	D.	Cotang.	Secant	Parts	Cosine	m	′ ″
30	0	8·639680	1446	11·360320	8·640093	1449	11·359907	10·000414		9·999586	50	30
30	2	8·641124	1442	11·358876	8·641540	1445	11·358460	10·000416	1″ 0	9·999584	58	30
31	4	8·642563	1437	11·357437	8·642982	1440	11·357018	10·000419	2 0	9·999581	50	29
30	6	8·643998	1433	11·356002	8·644420	1435	11·355580	10·000422	3 0	9·999578	54	30
32	8	8·645428	1427	11·354572	8·645853	1431	11·354147	10·000425	4 0	9·999575	52	28
30	10	8·646854	1423	11·353146	8·647281	1425	11·352719	10·000427	5 0	9·999573	50	30
33	12	8·648274	1419	11·351726	8·648704	1421	11·351296	10·000430	6 1	9·999570	48	27
30	14	8·649690	1413	11·350310	8·650123	1417	11·349877	10·000433	7 1	9·999567	46	30
34	16	8·651102	1410	11·348898	8·651537	1412	11·348463	10·000436	8 1	9·999564	44	26
30	18	8·652508	1404	11·347492	8·652947	1407	11·347053	10·000439	9 1	9·999561	42	30
35	20	8·653911	1400	11·346089	8·654352	1403	11·345648	10·000442	10 1	9·999558	40	25
30	22	8·655308	1396	11·344692	8·655753	1399	11·344247	10·000444	11 1	9·999556	38	30
36	24	8·656702	1391	11·343298	8·657149	1393	11·342851	10·000447	12 1	9·999553	36	24
30	26	8·658090	1386	11·341910	8·658541	1390	11·341459	10·000450	13 1	9·999550	34	30
37	28	8·659475	1382	11·340525	8·659928	1385	11·340072	10·000453	14 1	9·999547	32	23
30	30	8·660855	1378	11·339145	8·661311	1381	11·338689	10·000456	15 1	9·999544	30	30
38	32	8·662230	1373	11·337770	8·662689	1376	11·337311	10·000459	16 2	9·999541	28	22
30	34	8·663602	1370	11·336398	8·664063	1372	11·335937	10·000462	17 2	9·999538	26	30
39	36	8·664968	1364	11·335032	8·665433	1367	11·334567	10·000465	18 2	9·999535	24	21
30	38	8·666331	1361	11·333669	8·666799	1364	11·333201	10·000468	19 2	9·999532	22	30
40	40	8·667689	1356	11·332311	8·668160	1359	11·331840	10·000471	20 2	9·999529	20	20
30	42	8·669043	1352	11·330957	8·669517	1355	11·330483	10·000473	21 2	9·999527	18	30
41	44	8·670393	1348	11·329607	8·670870	1351	11·329130	10·000476	22 2	9·999524	16	19
30	46	8·671739	1343	11·328261	8·672218	1346	11·327782	10·000479	23 2	9·999521	14	30
42	48	8·673080	1340	11·326920	8·673563	1343	11·326437	10·000482	24 2	9·999518	12	18
30	50	8·674418	1335	11·325582	8·674903	1338	11·325097	10·000485	25 2	9·999515	10	30
43	52	8·675751	1331	11·324249	8·676239	1334	11·323761	10·000488	26 3	9·999512	8	17
30	54	8·677080	1327	11·322920	8·677572	1330	11·322428	10·000491	27 3	9·999509	6	30
44	56	8·678405	1323	11·321595	8·678900	1326	11·321100	10·000494	28 3	9·999506	4	6
30	58	8·679726	1319	11·320274	8·680224	1322	11·319776	10·000497	29 3	9·999503	2	30
45	11	8·681043	1315	11·318957	8·681544	1318	11·318456	10·000500	30 3	9·999500	49	15
30	2	8·682356	1311	11·317644	8·682860	1314	11·317140	10·000503	1 0	9·999497	58	30
46	4	8·683665	1308	11·316335	8·684172	1311	11·315828	10·000507	2 0	9·999493	56	14
30	6	8·684971	1303	11·315029	8·685480	1306	11·314520	10·000510	3 0	9·999490	54	30
47	8	8·686272	1299	11·313728	8·686784	1302	11·313216	10·000513	4 0	9·999487	52	13
30	10	8·687569	1295	11·312431	8·688085	1299	11·311915	10·000516	5 1	9·999484	50	30
48	12	8·688863	1292	11·311137	8·689381	1294	11·310619	10·000519	6 1	9·999481	48	12
30	14	8·690152	1288	11·309848	8·690674	1291	11·309326	10·000522	7 1	9·999478	46	30
49	16	8·691438	1283	11·308562	8·691963	1287	11·308037	10·000525	8 1	9·999475	44	11
30	18	8·692720	1280	11·307280	8·693248	1283	11·306752	10·000528	9 1	9·999472	42	30
50	20	8·693998	1277	11·306002	8·694529	1280	11·305471	10·000531	10 1	9·999469	40	10
30	22	8·695272	1272	11·304728	8·695807	1275	11·304193	10·000534	11 1	9·999466	38	30
51	24	8·696543	1269	11·303457	8·697081	1272	11·302919	10·000537	12 1	9·999463	36	9
30	26	8·697810	1265	11·302190	8·698351	1268	11·301649	10·000541	13 1	9·999459	34	30
52	28	8·699073	1262	11·300927	8·699617	1265	11·300383	10·000544	14 1	9·999456	32	8
30	30	8·700333	1257	11·299667	8·700880	1261	11·299120	10·000547	15 2	9·999453	30	30
53	32	8·701589	1255	11·298411	8·702139	1257	11·297861	10·000550	16 2	9·999450	28	7
30	34	8·702841	1250	11·297159	8·703395	1254	11·296605	10·000553	17 2	9·999447	26	30
54	36	8·704090	1247	11·295910	8·704646	1250	11·295354	10·000557	18 2	9·999443	24	6
30	38	8·705335	1243	11·294665	8·705895	1247	11·294105	10·000560	19 2	9·999440	22	30
55	40	8·706577	1240	11·293423	8·707140	1243	11·292860	10·000563	20 2	9·999437	20	5
30	42	8·707815	1236	11·292185	8·708381	1239	11·291619	10·000566	21 2	9·999434	18	30
56	44	8·709049	1233	11·290951	8·709618	1236	11·290382	10·000569	22 2	9·999431	16	4
30	46	8·710280	1229	11·289720	8·710853	1233	11·289147	10·000573	23 2	9·999427	14	30
57	48	8·711507	1226	11·288493	8·712083	1228	11·287917	10·000576	24 2	9·999424	12	3
30	50	8·712731	1222	11·287268	8·713311	1226	11·286689	10·000579	25 3	9·999421	10	30
58	52	8·713952	1219	11·286048	8·714534	1222	11·285466	10·000582	26 3	9·999418	8	2
30	54	8·715169	1216	11·284831	8·715755	1219	11·284245	10·000586	27 3	9·999414	6	30
59	56	8·716383	1212	11·283617	8·716972	1215	11·283028	10·000589	28 3	9·999411	4	1
30	58	8·717593	1208	11·282406	8·718186	1212	11·281814	10·000592	29 3	9·999408	2	30
60	12	8·718800	1205	11·281200	8·719396	1209	11·280604	10·000596	30 3	9·999404	0	0
′ ″	m. s.	Cosine	D.	Secant	Cotang.	D.	Tangent	Cosec.	Parts	Sine	m.	′ ″

87° — 5h 48m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 12m — 3°

′ ″	m. s.	Sine	D.	Cosec.	Tangent	D.	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	8·718800	1205	11·281200	8·719396	1209	11·280604	10·000596		9·999404	48	60
30	2	8·720004	1202	11·279996	8·720603	1205	11·279397	10·000599	1″ 0	9·999401	58	30
1	4	8·721204	1199	11·278796	8·721806	1202	11·278194	10·000602	2 0	9·999398	56	59
30	6	8·722401	1195	11·277599	8·723007	1198	11·276993	10·000606	3 0	9·999394	54	30
2	8	8·723595	1192	11·276405	8·724204	1196	11·275796	10·000609	4 0	9·999391	52	58
30	10	8·724785	1189	11·275215	8·725397	1192	11·274603	10·000612	5 1	9·999388	50	30
3	12	8·725972	1185	11·274028	8·726588	1189	11·273412	10·000616	6 1	9·999384	48	57
30	14	8·727156	1183	11·272844	8·727775	1185	11·272225	10·000619	7 1	9·999381	46	30
4	16	8·728337	1179	11·271663	8·728959	1183	11·271041	10·000622	8 1	9·999378	44	56
30	18	8·729514	1176	11·270486	8·730140	1179	11·269860	10·000626	9 1	9·999374	42	30
5	20	8·730688	1172	11·269312	8·731317	1176	11·268683	10·000629	10 1	9·999371	40	55
30	22	8·731859	1170	11·268141	8·732492	1173	11·267508	10·000633	11 1	9·999367	38	30
6	24	8·733027	1166	11·266973	8·733663	1170	11·266337	10·000636	12 1	9·999364	36	54
30	26	8·734192	1163	11·265808	8·734831	1166	11·265169	10·000639	13 1	9·999361	34	30
7	28	8·735354	1160	11·264646	8·735996	1164	11·264004	10·000643	14 2	9·999357	32	53
30	30	8·736512	1157	11·263488	8·737158	1160	11·262842	10·000646	15 2	9·999354	30	30
8	32	8·737667	1154	11·262333	8·738317	1158	11·261683	10·000650	16 2	9·999350	28	52
30	34	8·738820	1151	11·261180	8·739473	1154	11·260527	10·000653	17 2	9·999347	26	30
9	36	8·739969	1148	11·260031	8·740626	1151	11·259374	10·000657	18 2	9·999343	24	51
30	38	8·741115	1144	11·258885	8·741776	1148	11·258224	10·000660	19 2	9·999340	22	30
10	40	8·742259	1142	11·257741	8·742922	1146	11·257078	10·000664	20 2	9·999336	20	50
30	42	8·743399	1139	11·256601	8·744066	1142	11·255934	10·000667	21 2	9·999333	18	30
11	44	8·744536	1136	11·255464	8·745207	1139	11·254793	10·000671	22 3	9·999329	16	49
30	46	8·745670	1132	11·254330	8·746344	1136	11·253656	10·000674	23 3	9·999326	14	30
12	48	8·746802	1130	11·253198	8·747479	1134	11·252521	10·000678	24 3	9·999322	12	48
30	50	8·747930	1127	11·252070	8·748611	1130	11·251389	10·000681	25 3	9·999319	10	30
13	52	8·749055	1124	11·250945	8·749740	1127	11·250260	10·000685	26 3	9·999315	8	47
30	54	8·750178	1121	11·249822	8·750866	1125	11·249134	10·000688	27 3	9·999312	6	30
14	56	8·751297	1118	11·248703	8·751989	1122	11·248011	10·000692	28 3	9·999308	4	46
30	58	8·752414	1115	11·247586	8·753109	1119	11·246891	10·000695	29 3	9·999305	2	30
15	13	8·753528	1113	11·246472	8·754227	1116	11·245773	10·000699	30 3	9·999301	47	45
30	2	8·754639	1109	11·245361	8·755341	1113	11·244659	10·000703	1 0	9·999297	58	30
16	4	8·755747	1107	11·244253	8·756453	1110	11·243547	10·000706	2 0	9·999294	56	44
30	6	8·756852	1104	11·243148	8·757562	1107	11·242438	10·000710	3 0	9·999290	54	30
17	8	8·757955	1101	11·242045	8·758668	1105	11·241332	10·000713	4 0	9·999287	52	43
30	10	8·759054	1098	11·240946	8·759771	1102	11·240229	10·000717	5 1	9·999283	50	30
18	12	8·760151	1096	11·239849	8·760872	1099	11·239128	10·000721	6 1	9·999279	48	42
30	14	8·761245	1092	11·238755	8·761970	1097	11·238030	10·000724	7 1	9·999276	46	30
19	16	8·762337	1090	11·237663	8·763065	1093	11·236935	10·000728	8 1	9·999272	44	41
30	18	8·763425	1088	11·236575	8·764157	1091	11·235843	10·000732	9 1	9·999268	42	30
20	20	8·764511	1084	11·235489	8·765246	1088	11·234754	10·000735	10 1	9·999265	40	40
30	22	8·765594	1082	11·234406	8·766333	1086	11·233667	10·000739	11 1	9·999261	38	30
21	24	8·766675	1079	11·233325	8·767417	1083	11·232583	10·000743	12 1	9·999257	36	39
30	26	8·767752	1076	11·232248	8·768499	1080	11·231501	10·000746	13 2	9·999254	34	30
22	28	8·768828	1074	11·231172	8·769578	1077	11·230422	10·000750	14 2	9·999250	32	38
30	30	8·769900	1071	11·230100	8·770654	1075	11·229346	10·000754	15 2	9·999246	30	30
23	32	8·770970	1069	11·229030	8·771727	1072	11·228273	10·000758	16 2	9·999242	28	37
30	34	8·772037	1065	11·227963	8·772798	1070	11·227202	10·000761	17 2	9·999239	26	30
24	36	8·773101	1064	11·226899	8·773866	1067	11·226134	10·000765	18 2	9·999235	24	36
30	38	8·774163	1060	11·225837	8·774932	1064	11·225068	10·000769	19 2	9·999231	22	30
25	40	8·775223	1058	11·224777	8·775995	1062	11·224005	10·000773	20 2	9·999227	20	35
30	42	8·776279	1056	11·223721	8·777056	1059	11·222944	10·000776	21 3	9·999224	18	30
26	44	8·777333	1053	11·222667	8·778114	1057	11·221886	10·000780	22 3	9·999220	16	34
30	46	8·778385	1050	11·221615	8·779169	1054	11·220831	10·000784	23 3	9·999216	14	30
27	48	8·779434	1048	11·220566	8·780222	1051	11·219778	10·000788	24 3	9·999212	12	33
30	50	8·780480	1045	11·219520	8·781272	1049	11·218728	10·000792	25 3	9·999208	10	30
28	52	8·781524	1043	11·218476	8·782320	1047	11·217680	10·000795	26 3	9·999205	8	32
30	54	8·782566	1040	11·217434	8·783365	1044	11·216635	10·000799	27 3	9·999201	6	30
29	56	8·783605	1037	11·216395	8·784408	1041	11·215592	10·000803	28 3	9·999197	4	31
30	58	8·784641	1036	11·215359	8·785448	1040	11·214552	10·000807	29 4	9·999193	2	30
30	14	8·785675	1032	11·214325	8·786486	1036	11·213514	10·000811	30 4	9·999189	0	30
′ ″	m.	Cosine	D.	Secant	Cotang.	D.	Tangent	Cosec.	Parts	Sine	m.	′ ″

86° — 5h 46m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0^h 14m — 3°

′ ″	m. s.	Sine	D.	Cosec.	Tangent	D.	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	8·785675	1032	11·214325	8·786486	1036	11·213514	10·000811		9·999189	46	30
30	2	8·786707	1031	11·213293	8·787521	1034	11·212479	10·000815	1″ 0	9·999185	58	30
31	4	8·787736	1028	11·212264	8·788554	1032	11·211446	10·000819	2 0	9·999181	56	29
30	6	8·788762	1025	11·211238	8·789585	1029	11·210415	10·000822	3 0	9·999178	54	30
32	8	8·789787	1023	11·210213	8·790613	1027	11·209387	10·000826	4 1	9·999174	52	28
30	10	8·790808	1020	11·209192	8·791639	1025	11·208361	10·000830	5 1	9·999170	50	30
33	12	8·791828	1019	11·208172	8·792662	1022	11·207338	10·000834	6 1	9·999166	48	27
30	14	8·792845	1015	11·207155	8·793683	1019	11·206317	10·000838	7 1	9·999162	46	30
34	16	8·793859	1014	11·206141	8·794701	1018	11·205299	10·000842	8 1	9·999158	44	26
30	18	8·794872	1011	11·205128	8·795718	1015	11·204282	10·000846	9 1	9·999154	42	30
35	20	8·795881	1009	11·204119	8·796731	1012	11·203269	10·000850	10 1	9·999150	40	25
30	22	8·796889	1006	11·203111	8·797743	1011	11·202257	10·000854	11 1	9·999146	38	30
36	24	8·797894	1004	11·202106	8·798752	1008	11·201248	10·000858	12 2	9·999142	36	24
30	26	8·798897	1001	11·201103	8·799759	1005	11·200241	10·000862	13 2	9·999138	34	30
37	28	8·799897	1000	11·200103	8·800763	1004	11·199237	10·000866	14 2	9·999134	32	23
30	30	8·800896	997	11·199104	8·801765	1001	11·198235	10·000870	15 2	9·999130	30	30
38	32	8·801892	995	11·198108	8·802765	998	11·197235	10·000874	16 2	9·999126	28	22
30	34	8·802885	992	11·197115	8·803763	997	11·196237	10·000878	17 2	9·999122	26	30
39	36	8·803876	990	11·196124	8·804758	994	11·195242	10·000882	18 2	9·999118	24	21
30	38	8·804866	988	11·195134	8·805751	992	11·194249	10·000886	19 3	9·999114	22	30
40	40	8·805852	986	11·194148	8·806742	990	11·193258	10·000890	20 3	9·999110	20	20
30	42	8·806837	983	11·193163	8·807731	987	11·192269	10·000894	21 3	9·999106	18	30
41	44	8·807819	982	11·192181	8·808717	986	11·191283	10·000898	22 3	9·999102	16	19
30	46	8·808799	979	11·191201	8·809701	983	11·190299	10·000902	23 3	9·999098	14	30
42	48	8·809777	976	11·190223	8·810683	981	11·189317	10·000906	24 3	9·999094	12	18
30	50	8·810753	975	11·189247	8·811663	978	11·188337	10·000910	25 3	9·999090	10	30
43	52	8·811726	972	11·188274	8·812641	977	11·187359	10·000914	26 3	9·999086	8	17
30	54	8·812698	971	11·187302	8·813616	974	11·186384	10·000918	27 4	9·999082	6	30
44	56	8·813667	968	11·186333	8·814589	972	11·185411	10·000923	28 4	9·999077	4	16
30	58	8·814634	965	11·185366	8·815560	970	11·184440	10·000927	29 4	9·999073	2	30
45	15	8·815599	964	11·184401	8·816529	968	11·183471	10·000931	30 4	9·999069	45	15
30	2	8·816561	962	11·183439	8·817496	966	11·182504	10·000935	1 0	9·999065	58	30
46	4	8·817522	959	11·182478	8·818461	963	11·181539	10·000939	2 0	9·999061	56	14
30	6	8·818480	958	11·181520	8·819423	962	11·180577	10·000943	3 0	9·999057	54	30
47	8	8·819436	955	11·180564	8·820384	959	11·179616	10·000947	4 1	9·999053	52	13
30	10	8·820390	953	11·179610	8·821342	958	11·178658	10·000952	5 1	9·999048	50	30
48	12	8·821343	951	11·178657	8·822298	955	11·177702	10·000956	6 1	9·999044	48	12
30	14	8·822292	949	11·177708	8·823253	953	11·176747	10·000960	7 1	9·999040	46	30
49	16	8·823240	947	11·176760	8·824205	951	11·175795	10·000964	8 1	9·999036	44	11
30	18	8·824186	944	11·175814	8·825155	949	11·174845	10·000968	9 1	9·999032	42	30
50	20	8·825130	943	11·174870	8·826103	947	11·173897	10·000973	10 1	9·999027	40	10
30	22	8·826072	941	11·173928	8·827049	945	11·172951	10·000977	11 2	9·999023	38	30
51	24	8·827011	938	11·172989	8·827992	943	11·172008	10·000981	12 2	9·999019	36	9
30	26	8·827949	937	11·172051	8·828934	941	11·171066	10·000985	13 2	9·999015	34	30
52	28	8·828884	934	11·171116	8·829874	938	11·170126	10·000990	14 2	9·999010	32	8
30	30	8·829818	933	11·170182	8·830812	937	11·169188	10·000994	15 2	9·999006	30	30
53	32	8·830749	931	11·169251	8·831748	935	11·168252	10·000998	16 2	9·999002	28	7
30	34	8·831679	928	11·168321	8·832682	933	11·167318	10·001003	17 2	9·998997	26	30
54	36	8·832607	927	11·167393	8·833613	931	11·166387	10·001007	18 3	9·998993	24	6
30	38	8·833532	924	11·166468	8·834543	929	11·165457	10·001011	19 3	9·998989	22	30
55	40	8·834456	923	11·165544	8·835471	926	11·164529	10·001016	20 3	9·998984	20	5
30	42	8·835377	920	11·164623	8·836397	925	11·163603	10·001020	21 3	9·998980	18	30
56	44	8·836297	919	11·163703	8·837321	923	11·162679	10·001024	22 3	9·998976	16	4
30	46	8·837215	917	11·162785	8·838243	922	11·161757	10·001029	23 3	9·998971	14	30
57	48	8·838130	915	11·161870	8·839163	919	11·160837	10·001033	24 3	9·998967	12	3
30	50	8·839044	912	11·160956	8·840081	917	11·159919	10·001037	25 4	9·998963	10	30
58	52	8·839956	911	11·160044	8·840998	915	11·159002	10·001042	26 4	9·998958	8	2
30	54	8·840866	909	11·159134	8·841912	914	11·158088	10·001046	27 4	9·998954	6	30
59	56	8·841774	907	11·158226	8·842825	911	11·157175	10·001050	28 4	9·998950	4	1
30	58	8·842680	906	11·157320	8·843735	910	11·156265	10·001055	29 4	9·998945	2	30
60	16	8·843585	903	11·156415	8·844644	907	11·155356	10·001059	30 4	9·998941	0	0
′ ″	m. s.	Cosine	D.	Secant	Cotang.	D	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

86° — 5^h 44m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 16m — 4°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	8·843585		11·156415	8·844644		11·155356	10·001059		9·998941	4m	60
30	2	8·844487	1″ 30	11·155513	8·845551	1″ 30	11·154449	10·001064	1″ 0	9·998936	58	30
1	4	8·845387	2 60	11·154613	8·846455	2 60	11·153545	10·001068	2 0	9·998932	56	59
30	6	8·846286	3 89	11·153714	8·847358	3 90	11·152642	10·001073	3 0	9·998927	54	30
2	8	8·847183	4 119	11·152817	8·848260	4 120	11·151740	10·001077	4 1	9·998923	52	58
30	10	8·848078	5 149	11·151922	8·849159	5 150	11·150841	10·001081	5 1	9·998919	50	30
3	12	8·848971	6 179	11·151029	8·850057	6 180	11·149943	10·001086	6 1	9·998914	48	57
30	14	8·849862	7 208	11·150138	8·850952	7 210	11·149048	10·001090	7 1	9·998910	46	30
4	16	8·850751	8 238	11·149249	8·851846	8 239	11·148154	10·001095	8 1	9·998905	44	56
30	18	8·851639	9 268	11·148361	8·852738	9 269	11·147262	10·001099	9 1	9·998901	42	30
5	20	8·852525	10 298	11·147475	8·853628	10 299	11·146372	10·001104	10 2	9·998896	40	55
30	22	8·853408	1 29	11·146592	8·854517	1 29	11·145483	10·001108	11 2	9·998892	38	30
6	24	8·854291	2 58	11·145709	8·855403	2 59	11·144597	10·001113	12 2	9·998887	36	54
30	26	8·855171	3 88	11·144829	8·856288	3 88	11·143712	10·001117	13 2	9·998883	34	30
7	28	8·856049	4 117	11·143951	8·857171	4 117	11·142829	10·001122	14 2	9·998878	32	53
30	30	8·856926	5 146	11·143074	8·858053	5 146	11·141947	10·001127	15 2	9·998873	30	30
8	32	8·857801	6 175	11·142199	8·858932	6 176	11·141068	10·001131	16 2	9·998869	28	52
30	34	8·858674	7 204	11·141326	8·859810	7 205	11·140190	10·001136	17 3	9·998864	26	30
9	36	8·859546	8 233	11·140454	8·860686	8 234	11·139314	10·001140	18 3	9·998860	24	51
30	38	8·860415	9 263	11·139585	8·861560	9 264	11·138440	10·001145	19 3	9·998855	22	30
10	40	8·861283	10 292	11·138717	8·862433	10 293	11·137567	10·001149	20 3	9·998851	20	50
30	42	8·862149	1 29	11·137851	8·863303	1 29	11·136697	10·001154	21 3	9·998846	18	30
11	44	8·863014	2 57	11·136986	8·864173	2 58	11·135827	10·001159	22 3	9·998841	16	49
30	46	8·863877	3 86	11·136123	8·865040	3 86	11·134960	10·001163	23 3	9·998837	14	30
12	48	8·864738	4 114	11·135262	8·865906	4 115	11·134094	10·001168	24 4	9·998832	12	48
30	50	8·865597	5 143	11·134403	8·866769	5 144	11·133231	10·001173	25 4	9·998827	10	30
13	52	8·866455	6 172	11·133545	8·867632	6 173	11·132368	10·001177	26 4	9·998823	8	47
30	54	8·867310	7 200	11·132690	8·868492	7 201	11·131508	10·001182	27 4	9·998818	6	30
14	56	8·868165	8 229	11·131835	8·869351	8 230	11·130649	10·001187	28 4	9·998813	4	46
30	58	8·869017	9 257	11·130983	8·870208	9 259	11·129792	10·001191	29 4	9·998809	2	30
15	1m	8·869868	10 286	11·130132	8·871064	10 288	11·128936	10·001196	30 5	9·998804	3m	45
30	2	8·870717	1 28	11·129283	8·871918	1 28	11·128082	10·001201	1 0	9·998799	58	30
16	4	8·871565	2 56	11·128435	8·872770	2 56	11·127230	10·001205	2 0	9·998795	56	44
30	6	8·872410	3 84	11·127590	8·873620	3 85	11·126380	10·001210	3 0	9·998790	54	30
17	8	8·873255	4 112	11·126745	8·874469	4 113	11·125531	10·001215	4 1	9·998785	52	43
30	10	8·874097	5 140	11·125903	8·875317	5 141	11·124683	10·001219	5 1	9·998781	50	30
18	12	8·874938	6 168	11·125062	8·876162	6 169	11·123838	10·001224	6 1	9·998776	48	42
30	14	8·875777	7 196	11·124223	8·877006	7 197	11·122994	10·001229	7 1	9·998771	46	30
19	16	8·876615	8 224	11·123385	8·877849	8 225	11·122151	10·001234	8 1	9·998766	44	41
30	18	8·877451	9 252	11·122549	8·878689	9 254	11·121311	10·001238	9 1	9·998762	42	30
20	20	8·878285	10 280	11·121715	8·879529	10 282	11·120471	10·001243	10 2	9·998757	40	40
30	22	8·879118	1 27	11·120882	8·880366	1 28	11·119634	10·001248	11 2	9·998752	38	30
21	24	8·879949	2 55	11·120051	8·881202	2 55	11·118798	10·001253	12 2	9·998747	36	39
30	26	8·880779	3 82	11·119221	8·882037	3 83	11·117963	10·001258	13 2	9·998742	34	30
22	28	8·881607	4 110	11·118393	8·882869	4 111	11·117131	10·001262	14 2	9·998738	32	38
30	30	8·882433	5 137	11·117567	8·883701	5 138	11·116299	10·001267	15 2	9·998733	30	30
23	32	8·883258	6 165	11·116742	8·884530	6 166	11·115470	10·001272	16 3	9·998728	28	37
30	34	8·884081	7 192	11·115919	8·885358	7 193	11·114642	10·001277	17 3	9·998723	26	30
24	36	8·884903	8 220	11·115097	8·886185	8 221	11·113815	10·001282	18 3	9·998718	24	36
30	38	8·885723	9 247	11·114277	8·887010	9 249	11·112990	10·001287	19 3	9·998713	22	30
25	40	8·886542	10 275	11·113458	8·887833	10 276	11·112167	10·001292	20 3	9·998708	20	35
30	42	8·887359	1 27	11·112641	8·888655	1 27	11·111345	10·001296	21 3	9·998704	18	30
26	44	8·888174	2 54	11·111826	8·889476	2 54	11·110524	10·001301	22 4	9·998699	16	34
30	46	8·888988	3 81	11·111012	8·890295	3 81	11·109705	10·001306	23 4	9·998694	14	30
27	48	8·889801	4 108	11·110199	8·891112	4 109	11·108888	10·001311	24 4	9·998689	12	33
30	50	8·890612	5 135	11·109388	8·891928	5 136	11·108072	10·001316	25 4	9·998684	10	30
28	52	8·891421	6 162	11·108579	8·892742	6 163	11·107258	10·001321	26 4	9·998679	8	32
30	54	8·892229	7 189	11·107771	8·893555	7 190	11·106445	10·001326	27 4	9·998674	6	30
29	56	8·893035	8 216	11·106965	8·894366	8 217	11·105634	10·001331	28 5	9·998669	4	31
30	58	8·893840	9 243	11·106160	8·895176	9 244	11·104824	10·001336	29 5	9·998664	2	30
30	2m	8·894643	10 270	11·105357	8·895984	10 271	11·104016	10·001341	30 5	9·998659	2m	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

85° — 5h 42m

TABLE XXXVII.—(*continued*).

LOG. SINES. COSINES, &c.

0h 18m — 4°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	8·894643		11·105357	8·895984		11·104016	10·001341		9·998659	42	30
30	2	8·895445	1″ 26	11·104555	8·896791	1″ 27	11·103209	10·001346	1″ 0	9·998654	58	30
31	4	8·896246	2 53	11·103754	8·897596	2 53	11·102404	10·001351	2 0	9·998649	56	29
30	6	8·897044	3 79	11·102956	8·898400	3 80	11·101600	10·001356	3 1	9·998644	54	30
32	8	8·897842	4 106	11·102158	8·899203	4 107	11·100797	10·001361	4 1	9·998639	52	28
30	10	8·898638	5 132	11·101362	8·900004	5 133	11·099996	10·001366	5 1	9·998634	50	30
33	12	8·899432	6 159	11·100568	8·900803	6 160	11·099197	10·001371	6 1	9·998629	48	27
30	14	8·900225	7 185	11·099775	8·901601	7 186	11·098399	10·001376	7 1	9·998624	46	30
34	16	8·901017	8 212	11·098983	8·902398	8 213	11·097602	10·001381	8 1	9·998619	44	26
30	18	8·901807	9 238	11·098193	8·903193	9 240	11·096807	10·001386	9 2	9·998614	42	30
35	20	8·902596	10 265	11·097404	8·903987	10 266	11·096013	10·001391	10 2	9·998609	40	25
30	22	8·903383	1 26	11·096617	8·904779	1 26	11·095221	10·001396	11 2	9·998604	38	30
36	24	8·904169	2 52	11·095831	8·905570	2 52	11·094430	10·001401	12 2	9·998599	36	24
30	26	8·904953	3 78	11·095047	8·906359	3 79	11·093641	10·001406	13 2	9·998594	34	30
37	28	8·905736	4 104	11·094264	8·907147	4 105	11·092853	10·001411	14 2	9·998589	32	23
30	30	8·906517	5 130	11·093483	8·907934	5 131	11·092066	10·001416	15 3	9·998584	30	30
38	32	8·907297	6 156	11·092703	8·908719	6 157	11·091281	10·001422	16 3	9·998578	28	22
30	34	8·908076	7 182	11·091924	8·909503	7 183	11·090497	10·001427	17 3	9·998573	26	30
39	36	8·908853	8 208	11·091147	8·910285	8 209	11·089715	10·001432	18 3	9·998568	24	21
30	38	8·909629	9 234	11·090371	8·911066	9 236	11·088934	10·001437	19 3	9·998563	22	30
40	40	8·910404	10 260	11·089596	8·911846	10 262	11·088154	10·001442	20 3	9·998558	20	20
30	42	8·911177	1 26	11·088823	8·912624	1 26	11·087376	10·001447	21 4	9·998553	18	30
41	44	8·911949	2 51	11·088051	8·913401	2 51	11·086599	10·001452	22 4	9·998548	16	19
30	46	8·912719	3 77	11·087281	8·914177	3 77	11·085823	10·001458	23 4	9·998542	14	30
42	48	8·913488	4 102	11·086512	8·914951	4 103	11·085049	10·001463	24 4	9·998537	12	18
30	50	8·914256	5 128	11·085744	8·915724	5 129	11·084276	10·001468	25 4	9·998532	10	30
43	52	8·915022	6 153	11·084978	8·916495	6 154	11·083505	10·001473	26 4	9·998527	8	17
30	54	8·915787	7 179	11·084213	8·917265	7 180	11·082735	10·001478	27 5	9·998522	6	30
44	56	8·916550	8 204	11·083450	8·918034	8 206	11·081966	10·001484	28 5	9·998516	4	16
30	58	8·917313	9 230	11·082687	8·918801	9 231	11·081199	10·001489	29 5	9·998511	2	30
45	19	8·918073	10 255	11·081927	8·919568	10 257	11·080432	10·001494	30 5	9·998506	41	15
30	2	8·918833	1 25	11·081167	8·920332	1 25	11·079668	10·001499	1 0	9·998501	58	30
46	4	8·919591	2 50	11·080409	8·921096	2 51	11·078904	10·001505	2 0	9·998495	56	14
30	6	8·920348	3 75	11·079652	8·921858	3 76	11·078142	10·001510	3 1	9·998490	54	30
47	8	8·921103	4 100	11·078897	8·922619	4 101	11·077381	10·001515	4 1	9·998485	52	13
30	10	8·921858	5 125	11·078142	8·923378	5 126	11·076622	10·001521	5 1	9·998479	50	30
48	12	8·922610	6 150	11·077390	8·924136	6 152	11·075864	10·001526	6 1	9·998474	48	12
30	14	8·923362	7 175	11·076638	8·924893	7 177	11·075107	10·001531	7 1	9·998469	46	30
49	16	8·924112	8 201	11·075888	8·925649	8 202	11·074351	10·001536	8 1	9·998464	44	11
30	18	8·924861	9 226	11·075139	8·926403	9 227	11·073597	10·001542	9 2	9·998458	42	30
50	20	8·925609	10 251	11·074391	8·927156	10 253	11·072844	10·001547	10 2	9·998453	40	10
30	22	8·926355	1 25	11·073645	8·927908	1 25	11·072092	10·001552	11 2	9·998448	38	30
51	24	8·927100	2 49	11·072900	8·928658	2 50	11·071342	10·001558	12 2	9·998442	36	9
30	26	8·927844	3 74	11·072156	8·929407	3 74	11·070593	10·001563	13 2	9·998437	34	30
52	28	8·928587	4 99	11·071413	8·930155	4 99	11·069845	10·001569	14 3	9·998431	32	8
30	30	8·929328	5 123	11·070672	8·930902	5 124	11·069098	10·001574	15 3	9·998426	30	30
53	32	8·930068	6 148	11·069932	8·931647	6 149	11·068353	10·001579	16 3	9·998421	28	7
30	34	8·930806	7 173	11·069194	8·932391	7 174	11·067609	10·001585	17 3	9·998415	26	30
54	36	8·931544	8 197	11·068456	8·933134	8 199	11·066866	10·001590	18 3	9·998410	24	6
30	38	8·932280	9 222	11·067720	8·933876	9 223	11·066124	10·001596	19 3	9·998404	22	30
55	40	8·933015	10 247	11·066985	8·934616	10 248	11·065384	10·001601	20 4	9·998399	20	5
30	42	8·933749	1 24	11·066251	8·935355	1 24	11·064645	10·001606	21 4	9·998394	18	30
56	44	8·934481	2 48	11·065519	8·936093	2 49	11·063907	10·001612	22 4	9·998388	16	4
30	46	8·935212	3 73	11·064788	8·936830	3 73	11·063170	10·001617	23 4	9·998383	14	30
57	48	8·935942	4 97	11·064058	8·937565	4 98	11·062435	10·001623	24 4	9·998377	12	3
30	50	8·936671	5 121	11·063329	8·938299	5 122	11·061701	10·001628	25 4	9·998372	10	30
58	52	8·937398	6 145	11·062602	8·939032	6 147	11·060968	10·001634	26 5	9·998366	8	2
30	54	8·938125	7 170	11·061875	8·939764	7 171	11·060236	10·001639	27 5	9·998361	6	30
59	56	8·938850	8 194	11·061150	8·940494	8 195	11·059506	10·001645	28 5	9·998355	4	1
30	58	8·939573	9 218	11·060427	8·941224	9 220	11·058776	10·001650	29 5	9·998350	2	30
60	20	8·940296	10 242	11·059704	8·941952	10 244	11·058048	10·001656	30 5	9·998344	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

85° — 5h 40m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

$0^h\ 20^m$ 5°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	8·940296		11·059704	8·941952		11·058048	10·001656		9·998344	40	60
30	2	8·941017	1″ 24	11·058983	8·942679	1″ 24	11·057321	10·001660	1″ 0	9·998339	58	30
1	4	8·941738	2 48	11·058262	8·943404	2 48	11·056596	10·001667	2 0	9·998333	56	59
30	6	8·942457	3 71	11·057543	8·944129	3 72	11·0558[illegible]1	10·001672	3 1	9·998328	54	30
2	8	8·943174	4 95	11·056826	8·944852	4 96	11·055148	10·001678	4 1	9·998322	52	58
30	10	8·943891	5 119	11·056109	8·945574	5 120	11·054426	10·001684	5 1	9·998316	50	30
3	12	8·944606	6 143	11·055394	8·946295	6 144	11·053705	10·001689	6 1	9·998311	48	57
30	14	8·945321	7 167	11·054679	8·947015	7 168	11·052985	10·001695	7 1	9·998305	46	30
4	16	8·946034	8 191	11·053966	8·947734	8 192	11·052266	10·001700	8 2	9·998300	44	56
30	18	8·946745	9 214	11·053255	8·948451	9 216	11·051549	10·001706	9 2	9·998294	42	30
5	20	8·947456	10 238	11·052544	8·949168	10 240	11·050832	10·001711	10 2	9·998289	40	55
30	22	8·948166	1 23	11·051834	8·949883	1 24	11·050117	10·001717	11 2	9·998283	38	30
6	24	8·948874	2 47	11·051126	8·950597	2 47	11·049403	10·001723	12 2	9·998277	36	54
30	26	8·949581	3 70	11·050419	8·951309	3 71	11·048691	10·001728	13 2	9·998272	34	30
7	28	8·950287	4 94	11·049713	8·952021	4 95	11·047979	10·001734	14 3	9·998266	32	53
30	30	8·950992	5 117	11·049008	8·952732	5 118	11·047268	10·001740	15 3	9·998260	30	30
8	32	8·951696	6 141	11·048304	8·953441	6 142	11·046559	10·001745	16 3	9·998255	28	52
30	34	8·952398	7 164	11·047602	8·954149	7 165	11·045851	10·001751	17 3	9·998249	26	30
9	36	8·953100	8 188	11·046900	8·954856	8 189	11·045144	10·001757	18 3	9·998243	24	51
30	38	8·953800	9 211	11·046200	8·955562	9 213	11·044438	10·001762	19 4	9·998238	22	30
10	40	8·954499	10 235	11·045501	8·956267	10 236	11·043733	10·001768	20 4	9·998232	20	50
30	42	8·955197	1 23	11·044803	8·956971	1 23	11·043029	10·001774	21 4	9·998226	18	30
11	44	8·955894	2 46	11·044106	8·957674	2 47	11·042326	10·001780	22 4	9·998220	16	49
30	46	8·956590	3 69	11·043410	8·958375	3 70	11·041625	10·001785	23 4	9·998215	14	30
12	48	8·957284	4 92	11·042716	8·959075	4 93	11·040925	10·001791	24 5	9·998209	12	48
30	50	8·957978	5 115	11·042022	8·959775	5 116	11·040225	10·001797	25 5	9·998203	10	30
13	52	8·958670	6 138	11·041330	8·960473	6 140	11·039527	10·001803	26 5	9·998197	8	47
30	54	8·959362	7 161	11·040638	8·961170	7 163	11·038830	10·001808	27 5	9·998192	6	30
14	56	8·960052	8 185	11·039948	8·961866	8 186	11·038134	10·001814	28 5	9·998186	4	46
30	58	8·960741	9 208	11·039259	8·962561	9 209	11·037439	10·001820	29 6	9·998180	2	30
15	21	8·961429	10 231	11·038571	8·963255	10 233	11·036745	10·001826	30 6	9·998174	39	45
30	2	8·962116	1 23	11·037884	8·963947	1 23	11·036053	10·001832	1 0	9·998168	58	30
16	4	8·962801	2 45	11·037199	8·964639	2 46	11·035361	10·001837	2 0	9·998163	56	44
30	6	8·963486	3 68	11·036514	8·965329	3 69	11·034671	10·001843	3 1	9·998157	54	30
17	8	8·964170	4 91	11·035830	8·966019	4 92	11·033981	10·001849	4 1	9·998151	52	43
30	10	8·964852	5 114	11·035148	8·966707	5 115	11·033293	10·001855	5 1	9·998145	50	30
18	12	8·965534	6 136	11·034466	8·967394	6 137	11·032606	10·001861	6 1	9·998139	48	42
30	14	8·966214	7 159	11·033786	8·968081	7 160	11·031919	10·001867	7 1	9·998133	46	30
19	16	8·966893	8 182	11·033107	8·968766	8 183	11·031234	10·001872	8 2	9·998128	44	41
30	18	8·967572	9 205	11·032428	8·969450	9 206	11·030550	10·001878	9 2	9·998122	42	30
20	20	8·968249	10 227	11·031751	8·970133	10 229	11·029867	10·001884	10 2	9·998116	40	40
30	22	8·968925	1 22	11·031075	8·970815	1 23	11·029185	10·001890	11 2	9·998110	38	30
21	24	8·969600	2 45	11·030400	8·971496	2 45	11·028504	10·001896	12 2	9·998104	36	39
30	26	8·970274	3 67	11·029726	8·972176	3 68	11·027824	10·001902	13 3	9·998098	34	30
22	28	8·970947	4 89	11·029053	8·972855	4 90	11·027145	10·001908	14 3	9·998092	32	38
30	30	8·971619	5 112	11·028381	8·973532	5 113	11·026468	10·001914	15 3	9·998086	30	30
23	32	8·972289	6 134	11·027711	8·974209	6 135	11·025791	10·001920	16 3	9·998080	28	37
30	34	8·972959	7 156	11·027041	8·974885	7 158	11·025115	10·001926	17 3	9·998074	26	30
24	36	8·973628	8 179	11·026372	8·975560	8 180	11·024440	10·001932	18 4	9·998068	24	36
30	38	8·974296	9 201	11·025704	8·976233	9 203	11·023767	10·001938	19 4	9·998062	22	30
25	40	8·974962	10 223	11·025038	8·976906	10 226	11·023094	10·001944	20 4	9·998056	20	35
30	42	8·975628	1 22	11·024372	8·977578	1 22	11·022422	10·001950	21 4	9·998050	18	30
20	44	8·976293	2 44	11·023707	8·978248	2 44	11·021752	10·001956	22 5	9·998044	16	34
30	46	8·976956	3 66	11·023044	8·978918	3 67	11·021082	10·001962	23 5	9·998038	14	30
27	48	8·977619	4 88	11·022381	8·979586	4 89	11·020414	10·001968	24 5	9·998032	12	33
30	50	8·978280	5 110	11·021720	8·980254	5 111	11·019746	10·001974	25 5	9·998026	10	30
28	52	8·978941	6 132	11·021059	8·980921	6 133	11·019079	10·001980	26 5	9·998020	8	32
30	54	8·979600	7 154	11·020400	8·981586	7 156	11·018414	10·001986	27 5	9·998014	6	30
29	56	8·980259	8 176	11·019741	8·982251	8 178	11·017749	10·001992	28 6	9·998008	4	31
30	58	8·980916	9 198	11·019084	8·982914	9 200	11·017086	10·001998	29 6	9·998002	2	30
30	22	8·981573	10 220	11·018427	8·983577	10 222	11·016423	10·002004	30 6	9·997996	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

84° $5^h\ 38^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

$0^h\ 22^m$						5°						
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	8·981573		11·018427	8·983577		11·016423	10·002004		9·997996	38	30
30	2	8·982228	1″ 22	11·017772	8·984238	1″ 22	11·015762	10·002010	1″ 0	9·997990	58	30
31	4	8·982883	2 43	11·017117	8·984899	2 44	11·015101	10·002016	2 0	9·997984	56	29
30	6	8·983536	3 65	11·016464	8·985559	3 66	11·014441	10·002022	3 1	9·997978	54	30
32	8	8·984189	4 87	11·015811	8·986217	4 88	11·013783	10·002028	4 1	9·997972	52	28
30	10	8·984840	5 109	11·015160	8·986875	5 110	11·013125	10·002035	5 1	9·997965	50	30
33	12	8·985491	6 130	11·014509	8·987532	6 131	11·012468	10·002041	6 1	9·997959	48	27
30	14	8·986141	7 152	11·013859	8·988187	7 153	11·011813	10·002047	7 1	9·997953	46	30
34	16	8·986789	8 174	11·013211	8·988842	8 175	11·011158	10·002053	8 2	9·997947	44	26
30	18	8·987437	9 195	11·012563	8·989496	9 197	11·010504	10·002059	9 2	9·997941	42	30
35	20	8·988083	10 217	11·011917	8·990149	10 219	11·009851	10·002065	10 2	9·997935	40	25
30	22	8·988729	1 21	11·011271	8·990801	1 22	11·009199	10·002071	11 2	9·997929	38	30
36	24	8·989374	2 43	11·010626	8·991451	2 43	11·008549	10·002078	12 2	9·997922	36	24
30	26	8·990017	3 64	11·009983	8·992101	3 65	11·007899	10·002084	13 3	9·997916	34	30
37	28	8·990660	4 85	11·009340	8·992750	4 86	11·007250	10·002090	14 3	9·997910	32	23
30	30	8·991302	5 107	11·008698	8·993398	5 108	11·006602	10·002096	15 3	9·997904	30	30
38	32	8·991943	6 128	11·008057	8·994045	6 129	11·005955	10·002103	16 3	9·997897	28	22
30	34	8·992583	7 150	11·007417	8·994692	7 151	11·005308	10·002109	17 4	9·997891	26	30
39	36	8·993222	8 171	11·006778	8·995337	8 173	11·004663	10·002115	18 4	9·997885	24	21
30	38	8·993860	9 192	11·006140	8·995981	9 194	11·004019	10·002121	19 4	9·997879	22	30
40	40	8·994497	10 214	11·005503	8·996624	10 216	11·003376	10·002128	20 4	9·997872	20	20
30	42	8·995133	1 21	11·004867	8·997267	1 21	11·002733	10·002134	21 4	9·997866	18	30
41	44	8·995768	2 42	11·004232	8·997908	2 43	11·002092	10·002140	22 5	9·997860	16	19
30	46	8·996402	3 63	11·003598	8·998549	3 64	11·001451	10·002146	23 5	9·997854	14	30
42	48	8·997036	4 84	11·002964	8·999188	4 85	11·000812	10·002153	24 5	9·997847	12	18
30	50	8·997668	5 105	11·002332	8·999827	5 106	11·000173	10·002159	25 5	9·997841	10	30
43	52	8·998299	6 126	11·001701	9·000465	6 128	10·999535	10·002165	26 5	9·997835	8	17
30	54	8·998930	7 147	11·001070	9·001102	7 149	10·998898	10·002172	27 6	9·997828	6	30
44	56	8·999560	8 168	11·000440	9·001738	8 170	10·998262	10·002178	28 6	9·997822	4	16
30	58	9·000188	9 189	10·999812	9·002373	9 191	10·997627	10·002184	29 6	9·997816	2	30
45	23	9·000816	10 210	10·999184	9·003007	10 213	10·996993	10·002191	30 6	9·997809	37	15
30	2	9·001443	1 21	10·998557	9·003640	1 21	10·996360	10·002197	1 0	9·997803	58	30
46	4	9·002069	2 41	10·997931	9·004272	2 42	10·995728	10·002203	2 0	9·997797	56	14
30	6	9·002694	3 62	10·997306	9·004904	3 63	10·995096	10·002210	3 1	9·997790	54	30
47	8	9·003318	4 83	10·996682	9·005534	4 84	10·994466	10·002216	4 1	9·997784	52	13
30	10	9·003941	5 104	10·996059	9·006164	5 105	10·993836	10·002223	5 1	9·997777	50	30
48	12	9·004563	6 124	10·995437	9·006792	6 126	10·993208	10·002229	6 1	9·997771	48	2
30	14	9·005185	7 145	10·994815	9·007420	7 147	10·992580	10·002235	7 1	9·997765	46	30
49	16	9·005805	8 166	10·994195	9·008047	8 167	10·991953	10·002242	8 2	9·997758	44	11
30	18	9·006425	9 187	10·993575	9·008673	9 188	10·991327	10·002248	9 2	9·997752	42	30
50	20	9·007044	10 207	10·992956	9·009298	10 209	10·990702	10·002255	10 2	9·997745	40	10
30	22	9·007661	1 20	10·992339	9·009923	1 21	10·990077	10·002261	11 2	9·997739	38	30
51	24	9·008278	2 41	10·991722	9·010546	2 41	10·989454	10·002268	12 3	9·997732	36	9
30	26	9·008894	3 61	10·991106	9·011169	3 62	10·988831	10·002274	13 3	9·997726	34	30
52	28	9·009510	4 82	10·990490	9·011790	4 83	10·988210	10·002281	14 3	9·997719	32	8
30	30	9·010124	5 102	10·989876	9·012411	5 103	10·987589	10·002287	15 3	9·997713	30	30
53	32	9·010737	6 123	10·989263	9·013031	6 124	10·986969	10·002294	16 3	9·997706	28	7
30	34	9·011350	7 143	10·988650	9·013650	7 145	10·986350	10·002300	17 4	9·997700	26	30
54	36	9·011962	8 163	10·988038	9·014268	8 165	10·985732	10·002307	18 4	9·997693	24	6
30	38	9·012572	9 184	10·987428	9·014886	9 186	10·985114	10·002313	19 4	9·997687	22	30
55	40	9·013182	10 204	10·986818	9·015502	10 207	10·984498	10·002320	20 4	9·997680	20	5
30	42	9·013791	1 20	10·986209	9·016118	1 20	10·983882	10·002326	21 4	9·997674	18	30
56	44	9·014400	2 40	10·985600	9·016732	2 41	10·983268	10·002333	22 5	9·997667	16	4
30	46	9·015007	3 61	10·984993	9·017346	3 61	10·982654	10·002339	23 5	9·997661	14	30
57	48	9·015613	4 81	10·984387	9·017959	4 81	10·982041	10·002346	24 5	9·997654	12	3
30	50	9·016219	5 101	10·983781	9·018572	5 102	10·981428	10·002353	25 5	9·997647	10	30
58	52	9·016824	6 121	10·983176	9·019183	6 122	10·980817	10·002359	26 5	9·997641	8	2
30	54	9·017428	7 141	10·982572	9·019794	7 143	10·980206	10·002366	27 6	9·997634	6	30
59	56	9·018031	8 161	10·981969	9·020403	8 163	10·979597	10·002372	28 6	9·997628	4	1
30	58	9·018633	9 182	10·981367	9·021012	9 183	10·978988	10·002379	29 6	9·997621	2	30
60	24	9·019235	10 201	10·980765	9·021620	10 204	10·978380	10·002386	30 6	9·997614	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
						84°					$5^h\ 36^m$	

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 24m					6°							
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·019235		10·980765	9·021620		10·978380	10·002386		9·997614	36	60
30	2	9·019835	1″ 20	10·980165	9·022227	1″ 20	10·977773	10·002392	1 0	9·997608	58	30
1	4	9·020435	2 40	10·979565	9·022834	2 40	10·977166	10·002399	2 0	9·997601	56	59
30	6	9·021034	3 60	10·978966	9·023439	3 60	10·976561	10·002406	3 1	9·997594	54	30
2	8	9·021632	4 79	10·978368	9·024044	4 80	10·975956	10·002412	4 1	9·997588	52	58
30	10	9·022229	5 99	10·977771	9·024648	5 101	10·975352	10·002419	5 1	9·997581	50	30
3	12	9·022825	6 119	10·977175	9·025251	6 121	10·974749	10·002426	6 1	9·997574	48	57
30	14	9·023421	7 139	10·976579	9·025853	7 141	10·974147	10·002432	7 2	9·997568	46	30
4	16	9·024016	8 159	10·975984	9·026455	8 161	10·973545	10·002439	8 2	9·997561	44	56
30	18	9·024610	9 179	10·975390	9·027055	9 181	10·972945	10·002446	9 2	9·997554	42	30
5	20	9·025203	10 199	10·974797	9·027655	10 201	10·972345	10·002453	10 2	9·997547	40	55
30	22	9·025795	1 20	10·974205	9·028254	1 20	10·971746	10·002459	11 2	9·997541	38	30
6	24	9·026386	2 39	10·973614	9·028852	2 40	10·971148	10·002466	12 3	9·997534	36	54
30	26	9·026977	3 59	10·973023	9·029450	3 59	10·970550	10·002473	13 3	9·997527	34	30
7	28	9·027567	4 78	10·972433	9·930046	4 79	10·969954	10·002480	14 3	9·997520	32	53
30	30	9·028156	5 98	10·971844	9·030642	5 99	10·969358	10·002486	15 3	9·997514	30	30
8	32	9·028744	6 118	10·971256	9·031237	6 119	10·968763	10·002493	16 4	9·997507	28	52
30	34	9·029332	7 137	10·970668	9·031831	7 139	10·968169	10·002500	17 4	9·997500	26	30
9	36	9·029918	8 157	10·970082	9·032425	8 159	10·967575	10·002507	18 4	9·997493	24	51
30	38	9·030504	9 176	10·969496	9·033017	9 178	10·966983	10·002513	19 4	9·997487	22	30
10	40	9·031089	10 196	10·968911	9·033609	10 198	10·966391	10·002520	20 5	9·997480	20	50
30	42	9·031673	1 19	10·968327	9·034200	1 20	10·965800	10·002527	21 5	9·997473	18	30
11	44	9·032257	2 39	10·967743	9·034791	2 39	10·965209	10·002534	22 5	9·997466	16	49
30	46	9·032839	3 58	10·967161	9·035380	3 59	10·964620	10·002541	23 5	9·997459	14	30
12	48	9·033421	4 77	10·966579	9·035969	4 78	10·964031	10·002548	24 5	9·997452	12	48
30	50	9·034002	5 97	10·965998	9·036557	5 98	10·963443	10·002555	25 6	9·997445	10	30
13	52	9·034582	6 116	10·965418	9·037144	6 117	10·962856	10·002561	26 6	9·997439	8	47
30	54	9·035162	7 135	10·064838	9·037730	7 137	10·962270	10·002568	27 6	9·997432	6	30
14	56	9·035741	8 155	10·964259	9·038316	8 157	10·961684	10·002575	28 6	9·997425	4	46
30	58	9·036319	9 174	10·963681	9·038901	9 176	10·961099	10·002582	29 7	9·997418	2	30
15	25	9·036896	10 193	10·963104	9·039485	10 196	10·960515	10·002589	30 7	9·997411	35	45
30	2	9·037472	1 19	10·962528	9·040068	1 19	10·959932	10·002596	1 0	9·997404	58	30
16	4	9·038048	2 38	10·961952	9·040651	2 39	10·959349	10·002603	2 0	9·997397	56	44
30	6	9·038623	3 57	10·961377	9·041232	3 58	10·958768	10·002610	3 1	9·997390	54	30
17	8	9·039197	4 76	10·960803	9·041813	4 77	10·958187	10·002617	4 1	9·997383	52	43
30	10	9·039770	5 95	10·960230	9·042394	5 97	10·957606	10·002624	5 1	9·997376	50	30
18	12	9·040342	6 114	10·959658	9·042973	6 116	10·957027	10·002631	6 1	9·997369	48	42
30	14	9·040914	7 133	10·959086	9·043552	7 135	10·956448	10·002638	7 2	9·997362	46	30
19	16	9·041485	8 153	10·958515	9·044130	8 154	10·955870	10·002645	8 2	9·997355	44	41
30	18	9·042055	9 172	10·957945	9·044707	9 174	10·955293	10·002652	9 2	9·997348	42	30
20	20	9·042625	10 191	10·957375	9·045284	10 193	10·954716	10·002659	10 2	9·997341	40	40
30	22	9·043194	1 19	10·956806	9·045859	1 19	10·954141	10·002666	11 3	9·997334	38	30
21	24	9·043762	2 38	10·956238	9·046434	2 38	10·953566	10·002673	12 3	9·997327	36	39
30	26	9·044329	3 56	10·955671	9·047009	3 57	10·952991	10·002680	13 3	9·997320	34	30
22	28	9·044895	4 75	10·955105	9·047582	4 76	10·952418	10·002687	14 3	9·997313	32	38
30	30	9·045461	5 94	10·954539	9·048155	5 95	10·951845	10·002694	15 4	9·997306	30	30
23	32	9·046026	6 113	10·953974	9·048727	6 114	10·951273	10·002701	16 4	9·997299	28	37
30	34	9·046590	7 132	10·953410	9·049298	7 133	10·950702	10·002708	17 4	9·997292	26	30
24	36	9·047154	8 151	10·952846	9·049869	8 153	10·950131	10·002715	18 4	9·997285	24	36
30	38	9·047717	9 169	10·952283	9·050439	9 172	10·949561	10·002722	19 4	9·997278	22	30
25	40	9·048279	10 188	10·951721	9·051008	10 191	10·948992	10·002729	20 5	9·997271	20	35
30	42	9·048840	1 19	10·951160	9·051576	1 19	10·948424	10·002736	21 5	9·997264	18	30
26	44	9·049400	2 37	10·950600	9·052144	2 38	10·947856	10·002743	22 5	9·997257	16	34
30	46	9·049960	3 56	10·950040	9·052711	3 56	10·947289	10·002751	23 5	9·997249	14	30
27	48	9·050519	4 74	10·949481	9·053277	4 75	10·946723	10·002758	24 6	9·997242	12	33
30	50	9·051078	5 93	10·948922	9·053843	5 94	10·946157	10·002765	25 5	9·997235	10	30
28	52	9·051635	6 111	10·948365	9·054407	6 113	10·945593	10·002772	26 6	9·997228	8	32
30	54	9·052192	7 130	10·947808	9·054972	7 132	10·945028	10·002779	27 7	9·997221	6	30
29	56	9·052749	8 149	10·947251	9·055535	8 150	10·944465	10·002786	28 7	9·997214	4	31
30	58	9·053304	9 167	10·946696	9·056098	9 169	10·943902	10·002794	29 7	9·997206	2	30
30	26	9·053859	10 186	10·946141	9·056659	10 188	10·943341	10·002801	30 7	9·997199	34	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
					83°						5h 34m	

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 26m — 6°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·053859		10·946141	9·056659		10·943341	10·002801		9·997199	34	30
30	2	9·054413	1″ 18	10·945587	9·057221	1″ 19	10·942779	10·002808	1″ 0	9·997192	58	30
31	4	9·054966	2 37	10·945034	9·057781	2 37	10·942219	10·002815	2 0	9·997185	56	29
30	6	9·055519	3 55	10·944481	9·058341	3 56	10·941659	10·002822	3 1	9·997178	54	30
32	8	9·056071	4 73	10·943929	9·058900	4 74	10·941100	10·002830	4 1	9·997170	52	28
30	10	9·056622	5 92	10·943378	9·059459	5 93	10·940541	10·002837	5 1	9·997163	50	30
33	12	9·057172	6 110	10·942828	9·060016	6 111	10·939984	10·002844	6 1	9·997156	48	27
30	14	9·057722	7 128	10·942278	9·060573	7 130	10·939427	10·002851	7 2	9·997149	46	30
34	16	9·058271	8 147	10·941729	9·061130	8 149	10·938870	10·002859	8 2	9·997141	44	26
30	18	9·058820	9 165	10·941180	9·061685	9 167	10·938315	19·002866	9 2	9·997134	42	30
35	20	9·059367	10 183	10·940633	9·062240	10 186	10·937760	10·002873	10 2	9·997127	40	25
30	22	9·059914	1 18	10·940086	9·062795	1 18	10·937205	10·002880	11 3	9·997120	38	30
36	24	9·060460	2 36	10·939540	9·063348	2 37	10·936652	10·002888	12 3	9·997112	36	24
30	26	9·061006	3 54	10·938994	9·063901	3 55	10·936099	10·002895	13 3	9·997105	34	30
37	28	9·061551	4 73	10·938449	9·064453	4 73	10·935547	10·002902	14 4	9·997098	32	23
30	30	9·062095	5 91	10·937905	9·065005	5 92	10·934995	10·002910	15 4	9·997090	30	30
38	32	9·062639	6 109	10·937361	9·065556	6 110	10·934444	10·002917	16 4	9·997083	28	22
30	34	9·063181	7 127	10·936819	9·066106	7 129	10·933894	10·002924	17 4	9·997076	26	30
39	36	9·063724	8 145	10·936276	9·066655	8 147	10·933345	10·002932	18 4	9·997068	24	21
30	38	9·064265	9 163	10·935735	9·067204	9 165	10·932796	10·002939	19 4	9·997061	22	30
40	40	9·064806	10 181	10·935194	9·067752	10 184	10·932248	10·002947	20 5	9·997053	20	20
30	42	9·065346	1 18	10·934654	9·068300	1 18	10·931700	10·002954	21 5	9·997046	18	30
41	44	9·065885	2 36	10·934115	9·068846	2 36	10·931154	10·002961	22 5	9·997039	16	19
30	46	9·066424	3 54	10·933576	9·069393	3 54	10·930607	10·002969	23 6	9·997031	14	30
42	48	9·066962	4 72	10·933038	9·069938	4 73	10·930062	10·002976	24 6	9·997024	12	18
30	50	9·067499	5 90	10·932501	9·070483	5 91	10·929517	10·002984	25 6	9·997016	10	30
43	52	9·068036	6 107	10·931964	9·071027	6 109	10·928973	10·002991	26 7	9·997009	8	17
30	54	9·068572	7 125	10·931428	9·071570	7 127	10·928430	10·002998	27 7	9·997002	6	30
44	56	9·069107	8 143	10·930893	9·072113	8 145	10·927887	10·003006	28 7	9·996994	4	16
30	58	9·069642	9 161	10·930358	9·072655	9 163	10·927345	10·003013	29 7	9·996987	2	30
45	27	9·070176	10 179	10·929824	9·073197	10 181	10·926803	10·003021	30 7	9·996979	33	15
30	2	9·070709	1 18	10·929291	9·073738	1 18	10·926262	10·003028	1 0	9·996972	58	30
46	4	9·071242	2 35	10·928758	9·074278	2 36	10·925722	10·003036	2 1	9·996964	56	14
30	6	9·071774	3 53	10·928226	9·074817	3 54	10·925183	10·003043	3 1	9·996957	54	30
47	8	9·072306	4 71	10·927694	9·075356	4 72	10·924644	10·003051	4 1	9·996949	52	13
30	10	9·072836	6 88	10·927164	9·075895	5 90	10·924105	10·003058	5 1	9·996942	50	30
48	12	9·073366	6 106	10·926634	9·076432	6 107	10·923568	10·003066	6 2	9·996934	48	12
30	14	9·073896	7 124	10·926104	9·076969	7 125	10·923031	10·003073	7 2	9·996927	46	30
49	16	9·074424	8 141	10·925576	9·077505	8 143	10·922495	10·003081	8 2	9·996919	44	11
30	18	9·074952	9 159	10·925047	9·078041	9 161	10·921959	10·003089	9 2	9·996911	42	30
50	20	9·075480	10 177	10·924520	9·078576	10 179	10·921424	10·003096	10 3	9·996904	40	10
30	22	9·076007	1 17	10·923993	9·079110	1 18	10·920890	10·003104	11 3	9·996896	38	30
51	24	9·076533	2 35	10·923467	9·079644	2 35	10·920356	10·003111	12 3	9·996889	36	9
30	26	9·077058	3 52	10·922942	9·080177	3 53	10·919823	10·003119	13 3	9·996881	34	30
52	28	9·077583	4 70	10·922417	9·080710	4 71	10·919290	10·003126	14 4	9·996874	32	8
30	30	9·078107	6 87	10·921893	9·081241	5 89	10·918759	10·003134	15 4	9·996866	30	30
53	32	9·078631	6 105	10·921369	9·081773	6 106	10·918227	10·003142	16 4	9·996858	28	7
30	34	9·079154	7 122	10·920846	9·082303	7 124	10·917697	10·003149	17 4	9·996851	26	30
54	36	9·079676	8 140	10·920324	9·082833	8 142	10·917167	10·003157	18 5	9·996843	24	6
30	38	9·080198	9 157	10·919802	9·083362	9 160	10·916638	10·003165	19 5	9·996835	22	30
55	40	9·080719	10 175	10·919281	9·083891	10 177	10·916109	10·003172	20 5	9·996828	20	5
30	42	9·081239	1 17	10·918761	9·084419	1 18	10·915581	10·003180	21 5	9·996820	18	30
56	44	9·081759	2 34	10·918241	9·084947	2 35	10·915053	10·003188	22 6	9·996812	16	4
30	46	9·082278	3 52	10·917722	9·085473	3 53	10·914527	10·003195	23 6	9·996805	14	30
57	48	9·082797	4 69	10·917203	9·086000	4 70	10·914000	10·003203	24 6	9·996797	12	3
30	50	9·083314	5 86	10·916685	9·086525	5 88	10·913475	10·003211	25 6	9·996789	10	30
58	52	9·083832	6 103	10·916168	9·087050	6 105	10·912950	10·003218	26 7	9·996782	8	2
30	54	9·084348	7 121	10·915652	9·087574	7 123	10·912426	10·003226	27 7	9·996774	6	30
59	56	9·084864	8 138	10·915136	9·088098	8 140	10·911902	10·003234	28 7	9·996766	4	1
30	58	9·085380	9 155	10·914620	9·088621	9 158	10·911379	10·003242	29 7	9·996758	2	30
60	28	9·085894	10 172	10·914106	9·089144	10 175	10·910856	10·003249	30 8	9·996751	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

83° — 5h 32m.

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 28m — 7°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·085894		10·914106	9·089144		10·910856	10·003249		9·996751	32	60
30	2	9·086409	1″ 17	10·913591	9·089666	1″ 17	10·910334	10·003257	1″ 0	9·996743	58	30
1	4	9·086922	2 34	10·913078	9·090187	2 35	10·909813	10·003265	2 1	9·996735	56	59
30	6	9·087435	3 51	10·912565	9·090708	3 52	10·909292	10·003273	3 1	9·996727	54	30
2	8	9·087947	4 68	10·912053	9·091228	4 69	10·908772	10·003280	4 1	9·996720	52	58
30	10	9·088459	5 85	10·911541	9·091747	5 87	10·908253	10·003288	5 1	9·996712	50	30
3	12	9·088970	6 102	10·911030	9·092266	6 104	10·907734	10·003296	6 2	9·996704	48	57
30	14	9·089480	7 119	10·910520	9·092784	7 121	10·907216	10·003304	7 2	9·996696	46	30
4	16	9·089990	8 136	10·910010	9·093302	8 138	10·906698	10·003312	8 2	9·996688	44	56
30	18	9·090500	9 153	10·909500	9·093819	9 156	10·906181	10·003320	9 2	9·996681	42	30
5	20	9·091008	10 170	10·908992	9·094336	10 173	10·905664	10·003327	10 3	9·996673	40	55
30	22	9·091516	1 17	10·908484	9·094851	1 17	10·905149	10·003335	11 3	9·996665	38	30
6	24	9·092024	2 34	10·907976	9·095367	2 34	10·904633	10·003343	12 3	9·996657	36	54
30	26	9·092530	3 50	10·907470	9·095881	3 51	10·904119	10·003351	13 3	9·996649	34	30
7	28	9·093037	4 67	10·906963	9·096395	4 68	10·903605	10·003359	14 4	9·996641	32	53
30	30	9·093542	5 84	10·906458	9·096909	5 86	10·903091	10·003367	15 4	9·996633	30	30
8	32	9·094047	6 101	10·905953	9·097422	6 103	10·902578	10·003375	16 4	9·996625	28	52
30	34	9·094552	7 118	10·905448	9·097934	7 120	10·902066	10·003383	17 4	9·996618	26	30
9	36	9·095056	8 135	10·904944	9·098446	8 137	10·901554	10·003390	18 5	9·996610	24	51
30	38	9·095559	9 151	10·904441	9·098957	9 154	10·901043	10·003398	19 5	9·996602	22	30
10	40	9·096062	10 168	10·903938	9·099468	10 171	10·900532	10·003406	20 5	9·996594	20	50
30	42	9·096564	1 17	10·903436	9·099978	1 17	10·900022	10·003414	21 6	9·996586	18	30
11	44	9·097065	2 33	10·902935	9·100487	2 34	10·899513	10·003422	22 6	9·996578	16	49
30	46	9·097566	3 50	10·902434	9·100996	3 51	10·899004	10·003430	23 6	9·996570	14	30
12	48	9·098066	4 67	10·901934	9·101504	4 68	10·898496	10·003438	24 6	9·996562	12	48
30	50	9·098566	5 83	10·901434	9·102012	5 85	10·897988	10·003446	25 7	9·996554	10	30
13	52	9·099065	6 100	10·900935	9·102519	6 101	10·897481	10·003454	26 7	9·996546	8	47
30	54	9·099564	7 116	10·900436	9·103026	7 118	10·896974	10·003462	27 7	9·996538	6	30
14	56	9·100062	8 133	10·899938	9·103532	8 135	10·896468	10·003470	28 7	9·996530	4	46
30	58	9·100559	9 150	10·899441	9·104037	9 152	10·895963	10·003478	29 8	9·996522	2	30
15	29	9·101056	10 166	10·898944	9·104542	10 169	10·895458	10·003486	30 8	9·996514	31	45
30	2	9·101552	1 16	10·898448	9·105046	1 17	10·894954	10·003494	1 0	9·996506	58	30
16	4	9·102048	2 33	10·897952	9·105550	2 33	10·894450	10·003502	2 1	9·996498	56	44
30	6	9·102543	3 49	10·897457	9·106053	3 50	10·893947	10·003510	3 1	9·996490	54	30
17	8	9·103037	4 66	10·896963	9·106556	4 67	10·893444	10·003518	4 1	9·996482	52	43
30	10	9·103531	5 82	10·896469	9·107058	5 84	10·892942	10·003527	5 1	9·996474	50	30
18	12	9·104025	6 99	10·895975	9·107559	6 100	10·892441	10·003535	6 2	9·996465	48	42
30	14	9·104517	7 115	10·895483	9·108060	7 117	10·891940	10·003543	7 2	9·996457	46	30
19	16	9·105010	8 132	10·894990	9·108560	8 134	10·891440	10·003551	8 2	9·996449	44	41
30	18	9·105501	9 148	10·894499	9·109060	9 150	10·890940	10·003559	9 2	9·996441	42	30
20	20	9·105992	10 165	10·894008	9·109559	10 167	10·890441	10·003567	10 3	9·996433	40	40
30	22	9·106483	1 16	10·893517	9·110058	1 17	10·889942	10·003575	11 3	9·996425	38	30
21	24	9·106973	2 33	10·893027	9·110556	2 33	10·889444	10·003583	12 3	9·996417	36	39
30	26	9·107462	3 49	10·892538	9·111054	3 50	10·888946	10·003591	13 4	9·996409	34	30
22	28	9·107951	4 65	10·892049	9·111551	4 66	10·888449	10·003600	14 4	9·996400	32	38
30	30	9·108439	5 81	10·891561	9·112047	5 83	10·887953	10·003608	15 4	9·996392	30	30
23	32	9·108927	6 98	10·891073	9·112543	6 99	10·887457	10·003616	16 4	9·996384	28	37
30	34	9·109414	7 114	10·890586	9·113039	7 116	10·886961	10·003624	17 5	9·996376	26	30
24	36	9·109901	8 130	10·890099	9·113533	8 132	10·886467	10·003632	18 5	9·996368	24	36
30	38	9·110387	9 146	10·889613	9·114028	9 149	10·885972	10·003641	19 5	9·996359	22	30
25	40	9·110873	10 163	10·889127	9·114521	10 165	10·885479	10·003649	20 5	9·996351	20	35
30	42	9·111358	1 16	10·888642	9·115015	1 16	10·884985	10·003657	21 6	9·996343	18	30
26	44	9·111842	2 32	10·888158	9·115507	2 33	10·884493	10·003665	22 6	9·996335	16	34
30	46	9·112326	3 48	10·887674	9·115999	3 49	10·884001	10·003674	23 6	9·996327	14	30
27	48	9·112809	4 64	10·887191	9·116491	4 65	10·883509	10·003682	24 7	9·996318	12	33
30	50	9·113292	5 80	10·886708	9·116982	5 82	10·883018	10·003690	25 7	9·996310	10	30
28	52	9·113774	6 96	10·886226	9·117472	6 98	10·882528	10·003698	26 7	9·996302	8	32
30	54	9·114256	7 112	10·885744	9·117962	7 114	10·882038	10·003707	27 7	9·996293	6	30
29	56	9·114737	8 129	10·885263	9·118452	8 131	10·881548	10·003715	28 8	9·996285	4	31
30	58	9·115218	9 145	10·884782	9·118941	9 147	10·881059	10·003723	29 8	9·996277	2	30
30	30	9·115698	10 161	10·884302	9·119429	10 163	10·880571	10·003731	30 8	9·996269	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

82° — 5h 30m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 30m — 7°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·115698		10·884302	9·119429		10·880571	10·003731		9·996269	30	30
30	2	9·116177	1″ 16	10·883823	9·119917	1″ 16	10·880083	10·003740	1″ 0	9·996260	58	30
31	4	9·116656	2 32	10·883344	9·120404	2 32	10·879596	10·003748	2 1	9·996252	56	29
30	6	9·117135	3 48	10·882865	9·120891	3 49	10·879109	10·003756	3 1	9·996244	54	30
32	8	9·117613	4 64	10·882387	9·121377	4 65	10·878623	10·003765	4 1	9·996235	52	28
30	10	9·118090	5 80	10·881910	9·121863	5 81	10·878137	10·003773	5 1	9·996227	50	30
33	12	9·118567	6 95	10·881433	9·122348	6 97	10·877652	10·003781	6 2	9·996219	48	27
30	14	9·119043	7 111	10·880957	9·122833	7 113	10·877167	10·003790	7 2	9·996210	46	30
34	16	9·119519	8 127	10·880481	9·123317	8 129	10·876683	10·003798	8 2	9·996202	44	26
30	18	9·119994	9 143	10·880006	9·123801	9 146	10·876199	10·003807	9 3	9·996193	42	30
35	20	9·120469	10 159	10·879531	9·124284	10 162	10·875716	10·003815	10 3	9·996185	40	25
30	22	9·120943	1 16	10·879057	9·124766	1 16	10·875234	10·003823	11 3	9·996177	38	30
36	24	9·121417	2 31	10·878583	9·125249	2 32	10·874751	10·003832	12 3	9·996168	36	24
30	26	9·121890	3 47	10·878110	9·125730	3 48	10·874270	10·003840	13 4	9·996160	34	30
37	28	9·122362	4 63	10·877638	9·126211	4 64	10·873789	10·003849	14 4	9·996151	32	23
30	30	9·122835	5 79	10·877165	9·126692	5 80	10·873308	10·003857	15 4	9·996143	30	30
38	32	9·123306	6 94	10·876694	9·127172	6 96	10·872828	10·003866	16 5	9·996134	28	22
30	34	9·123777	7 110	10·876223	9·127651	7 112	10·872349	10·003874	17 5	9·996126	26	30
39	36	9·124248	8 126	10·875752	9·128130	8 128	10·871870	10·003883	18 5	9·996117	24	21
30	38	9·124718	9 141	10·875282	9·128609	9 144	10·871391	10·003891	19 5	9·996109	22	30
40	40	9·125187	10 157	10·874813	9·129087	10 160	10·870913	10·003900	20 6	9·996100	20	20
30	42	9·125656	1 16	10·874344	9·129564	1 16	10·870436	10·003908	21 6	9·996092	18	30
41	44	9·126125	2 31	10·873875	9·130041	2 32	10·869959	10·003917	22 6	9·996083	16	19
30	46	9·126593	3 47	10·873407	9·130518	3 47	10·869482	10·003925	23 7	9·996075	14	30
42	48	9·127060	4 62	10·872940	9·130994	4 63	10·869006	10·003934	24 7	9·996066	12	18
30	50	9·127527	5 78	10·872473	9·131469	5 79	10·868531	10·003942	25 7	9·996058	10	30
43	52	9·127993	6 93	10·872007	9·131944	6 95	10·868056	10·003951	26 7	9·996049	8	17
30	54	9·128459	7 109	10·871541	9·132419	7 111	10·867581	10·003959	27 8	9·996041	6	30
44	56	9·128925	8 124	10·871075	9·132893	8 127	10·867107	10·003968	28 8	9·996032	4	16
30	58	9·129390	9 140	10·870610	9·133366	9 142	10·866634	10·003977	29 8	9·996023	2	30
45	31	9·129854	10 155	10·870146	9·133839	10 158	10·866161	10·003985	30 8	9·996015	29	15
30	2	9·130318	1 15	10·869682	9·134312	1 16	10·865688	10·003994	1 0	9·996006	58	30
46	4	9·130781	2 31	10·869219	9·134784	2 31	10·865216	10·004002	2 1	9·995998	56	14
30	6	9·131244	3 46	10·868756	9·135255	3 47	10·864745	10·004011	3 1	9·995989	54	30
47	8	9·131706	4 62	10·868294	9·135726	4 63	10·864274	10·004020	4 1	9·995980	52	13
30	10	9·132168	5 77	10·867832	9·136197	5 78	10·863803	10·004028	5 1	9·995972	50	30
48	12	9·132630	6 92	10·867370	9·136667	6 94	10·863333	10·004037	6 2	9·995963	48	12
30	14	9·133091	7 108	10·866909	9·137136	7 110	10·862864	10·004046	7 2	9·995954	46	30
49	16	9·133551	8 123	10·866449	9·137605	8 125	10·862395	10·004054	8 2	9·995946	44	11
30	18	9·134011	9 139	10·865989	9·138074	9 141	10·861926	10·004063	9 3	9·995937	42	30
50	20	9·134470	10 154	10·865530	9·138542	10 157	10·861458	10·004072	10 3	9·995928	40	10
30	22	9·134929	1 15	10·865071	9·139009	1 16	10·860991	10·004080	11 3	9·995920	38	30
51	24	9·135387	2 30	10·864613	9·139476	2 31	10·860524	10·004089	12 3	9·995911	36	9
30	26	9·135845	3 46	10·864155	9·139943	3 47	10·860057	10·004098	13 4	9·995902	34	30
52	28	9·136303	4 61	10·863697	9·140409	4 62	10·859591	10·004106	14 4	9·995894	32	8
30	30	9·136760	5 76	10·863240	9·140875	5 78	10·859125	10·004115	15 4	9·995885	30	30
53	32	9·137216	6 91	10·862784	9·141340	6 93	10·858660	10·004124	16 5	9·995876	28	7
30	34	9·137672	7 106	10·862328	9·141805	7 109	10·858195	10·004133	17 5	9·995867	26	30
54	36	9·138128	8 122	10·861872	9·142269	8 124	10·857731	10·004141	18 5	9·995859	24	6
30	38	9·138582	9 137	10·861418	9·142733	9 140	10·857267	10·004150	19 6	9·995850	22	30
55	40	9·139037	10 152	10·860963	9·143196	10 155	10·856804	10·004159	20 6	9·995841	20	5
30	42	9·139491	1 15	10·860509	9·143659	1 15	10·856341	10·004168	21 6	9·995832	18	30
56	44	9·139944	2 30	10·860056	9·144121	2 31	10·855879	10·004177	22 6	9·995823	16	4
30	46	9·140398	3 45	10·859602	9·144583	3 46	10·855417	10·004185	23 7	9·995815	14	30
57	48	9·140850	4 60	10·859150	9·145044	4 61	10·854956	10·004194	24 7	9·995806	12	3
30	50	9·141302	5 75	10·858698	9·145505	5 77	10·854495	10·004203	25 7	9·995797	10	30
58	52	9·141754	6 90	10·858246	9·145966	6 92	10·854034	10·004212	26 8	9·995788	8	2
30	54	9·142205	7 105	10·857795	9·146425	7 108	10·853575	10·004221	27 8	9·995779	6	30
59	56	9·142655	8 121	10·857345	9·146885	8 123	10·853115	10·004229	28 8	9·995771	4	1
30	58	9·143106	9 136	10·856894	9·147344	9 138	10·852656	10·004238	29 8	9·995762	2	30
60	32	9·143555	10 151	10·856445	9·147803	10 154	10·852197	10·004247	30 9	9·995753	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

82° — 5h 28m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 32m — 8°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·143555		10·856445	9·147803		10·852197	10·004247		9·995753	28	60
30	2	9·144005	1″ 15	10·855995	9·148261	1″ 15	10·851739	10·004256	1″ 0	9·995744	58	30
1	4	9·144453	2 30	10·855547	9·148718	2 30	10·851282	10·004265	2 1	9·995735	56	59
30	6	9·144902	3 45	10·855098	9·149175	3 46	10·850825	10·004274	3 1	9·995726	54	30
2	8	9·145349	4 59	10·854651	9·149632	4 61	10·850368	10·004283	4 1	9·995717	52	58
30	10	9·145797	5 74	10·854203	9·150088	5 76	10·849912	10·004292	5 1	9·995708	50	30
3	12	9·146243	6 89	10·853757	9·150544	6 91	10·849456	10·004301	6 2	9·995699	48	57
30	14	9·146690	7 104	10·853310	9·151000	7 106	10·849000	10·004310	7 2	9·995690	46	30
4	16	9·147136	8 119	10·852864	9·151454	8 122	10·848546	10·004319	8 2	9·995681	44	56
30	18	9·147581	9 134	10·852419	9·151909	9 137	10·848091	10·004328	9 3	9·995672	42	30
5	20	9·148026	10 149	10·851974	9·152363	10 152	10·847637	10·004336	10 3	9·995664	40	55
30	22	9·148471	1 15	10·851529	9·152816	1 15	10·847184	10·004345	11 3	9·995655	38	30
6	24	9·148915	2 29	10·851085	9·153269	2 30	10·846731	10·004354	12 4	9·995646	36	54
30	26	9·149358	3 44	10·850642	9·153722	3 45	10·846278	10·004363	13 4	9·995637	34	30
7	28	9·149802	4 59	10·850198	9·154174	4 60	10·845826	10·004372	14 4	9·995628	32	53
30	30	9·150244	5 74	10·849756	9·154626	5 75	10·845374	10·004381	15 4	9·995619	30	30
8	32	9·150686	6 88	10·849314	9·155077	6 90	10·844923	10·004390	16 5	9·995610	28	52
30	34	9·151128	7 103	10·848872	9·155528	7 105	10·844472	10·004400	17 5	9·995601	26	30
9	36	9·151569	8 118	10·848431	9·155978	8 120	10·844022	10·004409	18 5	9·995591	24	51
30	38	9·152010	9 133	10·847990	9·156428	9 135	10·843572	10·004418	19 6	9·995582	22	30
10	40	9·152451	10 147	10·847549	9·156877	10 150	10·843123	10·004427	20 6	9·995573	20	50
30	42	9·152891	1 15	10·847109	9·157326	1 15	10·842674	10·004436	21 6	9·995564	18	30
11	44	9·153330	2 29	10·846670	9·157775	2 30	10·842225	10·004445	22 7	9·995555	16	49
30	46	9·153769	3 44	10·846231	9·158223	3 45	10·841777	10·004454	23 7	9·995546	14	30
12	48	9·154208	4 58	10·845792	9·158671	4 60	10·841329	10·004463	24 7	9·995537	12	48
30	50	9·154646	5 73	10·845354	9·159118	5 75	10·840882	10·004472	25 7	9·995528	10	30
13	52	9·155083	6 87	10·844917	9·159565	6 89	10·840435	10·004481	26 8	9·995519	8	47
30	54	9·155521	7 102	10·844479	9·160011	7 104	10·839989	10·004490	27 8	9·995510	6	30
14	56	9·155957	8 117	10·844043	9·160457	8 119	10·839543	10·004499	28 8	9·995501	4	46
30	58	9·156394	9 131	10·843606	9·160902	9 134	10·839098	10·004509	29 9	9·995491	2	30
15	33	9·156830	10 146	10·843170	9·161347	10 149	10·838653	10·004518	30 9	9·995482	27	45
30	2	9·157265	1 14	10·842735	9·161792	1 15	10·838208	10·004527	1 0	9·995473	58	30
16	4	9·157700	2 29	10·842300	9·162236	2 29	10·837764	10·004536	2 1	9·995464	56	44
30	6	9·158135	3 43	10·841865	9·162680	3 44	10·837320	10·004545	3 1	9·995455	54	30
17	8	9·158569	4 58	10·841431	9·163123	4 59	10·836877	10·004554	4 1	9·995446	52	43
30	10	9·159002	5 72	10·840998	9·163566	5 74	10·836434	10·004564	5 2	9·995436	50	30
18	12	9·159435	6 87	10·840565	9·164008	6 88	10·835992	10·004573	6 2	9·995427	48	42
30	14	9·159868	7 101	10·840132	9·164450	7 103	10·835550	10·004582	7 2	9·995418	46	30
19	16	9·160301	8 115	10·839699	9·164892	8 118	10·835108	10·004591	8 3	9·995409	44	41
30	18	9·160732	9 130	10·839268	9·165333	9 133	10·834667	10·004601	9 3	9·995399	42	30
20	20	9·161164	10 144	10·838836	9·165774	10 147	10·834226	10·004610	10 3	9·995390	40	40
30	22	9·161595	1 14	10·838405	9·166214	1 15	10·833786	10·004619	11 4	9·995381	38	30
21	24	9·162025	2 29	10·837975	9·166654	2 29	10·833346	10·004628	12 4	9·995372	36	39
30	26	9·162456	3 43	10·837544	9·167093	3 44	10·832907	10·004638	13 4	9·995362	34	30
22	28	9·162885	4 57	10·837115	9·167532	4 58	10·832468	10·004647	14 4	9·995353	32	38
30	30	9·163315	5 71	10·836685	9·167971	5 73	10·832029	10·004656	15 5	9·995344	30	30
23	32	9·163743	6 86	10·836257	9·168409	6 88	10·831591	10·004666	16 5	9·995334	28	37
30	34	9·164172	7 100	10·835828	9·168847	7 102	10·831153	10·004675	17 5	9·995325	26	30
24	36	9·164600	8 114	10·835400	9·169284	8 117	10·830716	10·004684	18 6	9·995316	24	36
30	38	9·165027	9 128	10·834973	9·169721	9 131	10·830279	10·004694	19 6	9·995307	22	30
25	40	9·165454	10 143	10·834546	9·170157	10 146	10·829843	10·004703	20 6	9·995297	20	35
30	42	9·165881	1 14	10·834119	9·170593	1 14	10·829407	10·004712	21 7	9·995288	18	30
26	44	9·166307	2 28	10·833693	9·171029	2 29	10·828971	10·004722	22 7	9·995278	16	34
30	46	9·166733	3 42	10·833267	9·171464	3 43	10·828536	10·004731	23 7	9·995269	14	30
27	48	9·167159	4 57	10·832841	9·171899	4 58	10·828101	10·004740	24 7	9·995260	12	33
30	50	9·167584	5 71	10·832416	9·172333	5 72	10·827667	10·004750	25 8	9·995250	10	30
28	52	9·168008	6 85	10·831992	9·172767	6 87	10·827233	10·004759	26 8	9·995241	8	32
30	54	9·168432	7 99	10·831568	9·173201	7 101	10·826799	10·004769	27 8	9·995232	6	30
29	56	9·168856	8 113	10·831144	9·173634	8 116	10·826366	10·004778	28 9	9·995222	4	31
30	58	9·169279	9 127	10·830721	9·174067	9 130	10·825933	10·004787	29 9	9·995213	2	30
30	34	9·169702	10 141	10·830298	9·174499	10 145	10·825501	10·004797	30 9	9·995203	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

81° — 5h 26m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 34m — 8°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·169702		10·830298	9·174499	·	10·825501	10·004797		9·995203	26	30
30	2	9·170125	1″ 14	10·829875	9·174931	1″ 14	10·825069	10·004806	1″ 0	9·995194	58	30
31	4	9·170547	2 28	10·829453	9·175362	2 29	10·824638	10·004816	2 1	9·995184	56	29
30	6	9·170968	3 42	10·829032	9·175793	3 43	10·824207	10·004825	3 1	9·995175	54	30
32	8	9·171389	4 56	10·828611	9·176224	4 57	10·823776	10·004835	4 1	9·995165	52	28
30	10	9·171810	5 70	10·828190	9·176654	5 72	10·823346	10·004844	5 2	9·995156	50	30
33	12	9·172230	6 84	10·827770	9·177084	6 86	10·822916	10·004854	6 2	9·995146	48	27
30	14	9·172650	7 98	10·827350	9·177513	7 100	10·822487	10·004863	7 2	9·995137	46	30
34	16	9·173070	8 112	10·826930	9·177942	8 115	10·822058	10·004873	8 3	9·995127	44	26
30	18	9·173489	9 126	10·826511	9·178371	9 129	10·821629	10·004882	9 3	9·995118	42	30
35	20	9·173908	10 140	10·826092	9·178799	10 143	10·821201	10·004892	10 3	9·995108	40	25
30	22	9·174326	1 14	10·825674	9·179227	1 14	10·820773	10·004901	11 4	9·995099	38	30
36	24	9·174744	2 28	10·825256	9·179655	2 28	10·820345	10·004911	12 4	9·995089	36	24
30	26	9·175161	3 41	10·824839	9·180082	3 43	10·819918	10·004920	13 4	9·995080	34	30
37	28	9·175578	4 55	10·824422	9·180508	4 57	10·819492	10·004930	14 4	9·995070	32	23
30	30	9·175995	5 69	10·824005	9·180934	5 71	10·819066	10·004939	15 5	9·995061	30	30
38	32	9·176411	6 83	10·823589	9·181360	6 85	10·818640	10·004949	16 5	9·995051	28	22
30	34	9·176827	7 97	10·823173	9·181786	7 99	10·818214	10·004959	17 5	9·995041	26	30
39	36	9·177242	8 111	10·822758	9·182211	8 114	10·817789	10·004968	18 6	9·995032	24	21
30	38	9·177657	9 124	10·822343	9·182635	9 128	10·817365	10·004978	19 6	9·995022	22	30
40	40	9·178072	10 138	10·821928	9·183059	10 142	10·816941	10·004987	20 6	9·995013	20	20
30	42	9·178486	1 14	10·821514	9·183483	1 14	10·816517	10·004997	21 7	9·995003	18	30
41	44	9·178900	2 27	10·821100	9·183907	2 28	10·816093	10·005007	22 7	9·994993	16	19
30	46	9·179313	3 41	10·820687	9·184330	3 42	10·815670	10·005016	23 7	9·994984	14	30
42	48	9·179726	4 55	10·820274	9·184752	4 56	10·815248	10·005026	24 8	9·994974	12	18
30	50	9·180139	5 69	10·819861	9·185175	5 70	10·814825	10·005036	25 8	9·994964	10	30
43	52	9·180551	6 82	10·819449	9·185597	6 84	10·814403	10·005045	26 8	9·994955	8	17
30	54	9·180963	7 96	10·819037	9·186018	7 98	10·813982	10·005055	27 9	9·994945	6	30
44	56	9·181374	8 110	10·818626	9·186439	8 113	10·813561	10·005065	28 9	9·994935	4	16
30	58	9·181785	9 124	10·818215	9·186860	9 127	10·813140	10·005075	29 9	9·994925	2	30
45	35	9·182196	10 137	10·817804	9·187280	10 141	10·812720	10·005084	30 10	9·994916	25	15
30	2	9·182606	1 14	10·817394	9·187700	1 14	10·812300	10·005094	1 0	9·994906	58	30
46	4	9·183016	2 27	10·816984	9·188120	2 28	10·811880	10·005104	2 1	9·994896	56	14
30	6	9·183425	3 41	10·816575	9·188539	3 42	10·811461	10·005113	3 1	9·994887	54	30
47	8	9·183834	4 54	10·816166	9·188958	4 56	10·811042	10·005123	4 1	9·994877	52	13
30	10	9·184243	5 68	10·815757	9·189376	5 70	10·810624	10·005133	5 2	9·994867	50	30
48	12	9·184651	6 82	10·815349	9·189794	6 84	10·810206	10·005143	6 2	9·994857	48	12
30	14	9·185059	7 95	10·814941	9·190212	7 98	10·809788	10·005153	7 2	9·994847	46	30
49	16	9·185466	8 109	10·814534	9·190629	8 111	10·809371	10·005162	8 3	9·994838	44	11
30	18	9·185874	9 122	10·814126	9·191046	9 125	10·808954	10·005172	9 3	9·994828	42	30
50	20	9·186280	10 136	10·813720	9·191462	10 139	10·808538	10·005182	10 3	9·994818	40	10
30	22	9·186686	1 13	10·813314	9·191878	1 14	10·808122	10·005192	11 4	9·994808	38	30
51	24	9·187092	2 27	10·812908	9·192294	2 28	10·807706	10·005202	12 4	9·994798	36	9
30	26	9·187498	3 40	10·812502	9·192709	3 41	10·807291	10·005211	13 4	9·994789	34	30
52	28	9·187903	4 54	10·812097	9·193124	4 55	10·806876	10·005221	14 5	9·994779	32	8
30	30	9·188308	5 67	10·811692	9·193539	5 69	10·806461	10·005231	15 5	9·994769	30	30
53	32	9·188712	6 81	10·811288	9·193953	6 83	10·806047	10·005241	16 5	9·994759	28	7
30	34	9·189116	7 94	10·810884	9·194367	7 97	10·805633	10·005251	17 6	9·994749	26	30
54	36	9·189519	8 108	10·810481	9·194780	8 110	10·805220	10·005261	18 6	9·994739	24	6
30	38	9·189923	9 121	10·810077	9·195193	9 124	10·804807	10·005271	19 6	9·994729	22	30
55	40	9·190325	10 135	10·809675	9·195606	10 138	10·804394	10·005280	20 7	9·994720	20	5
30	42	9·190728	1 13	10·809272	9·196018	1 14	10·803982	10·005290	21 7	9·994710	18	30
56	44	9·191130	2 27	10·808870	9·196430	2 27	10·803570	10·005300	22 7	9·994700	16	4
30	46	9·191532	3 40	10·808468	9·196842	3 41	10·803158	10·005310	23 8	9·994690	14	30
57	48	9·191933	4 53	10·808067	9·197253	4 55	10·802747	10·005320	24 8	9·994680	12	3
30	50	9·192334	5 67	10·807666	9·197664	5 68	10·802336	10·005330	25 8	9·994670	10	30
58	52	9·192734	6 80	10·807266	9·198074	6 82	10·801926	10·005340	26 9	9·994660	8	2
30	54	9·193134	7 93	10·806866	9·198484	7 96	10·801516	10·005350	27 9	9·994650	6	30
59	56	9·193534	8 107	10·806466	9·198894	8 109	10·801106	10·005360	28 9	9·994640	4	1
30	58	9·193933	9 120	10·806067	9·199304	9 123	10·800696	10·005370	29 10	9·994630	2	30
60	36	9·194332	10 133	10·805668	9·199713	10 137	10·800287	10·005380	30 10	9·994620	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

81° — 5h 24m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 36m — 9°

′ ″	m.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m.	′ ″
0	0	9·194332		10·805668	9·199713		10·800287	10·005380		9·994620	24	60
30	2	9·194731	1″ 13	10·805269	9·200121	1″ 13	10·799879	10·005390	1″ 0	9·994610	58	30
1	4	9·195129	2 26	10·804871	9·200529	2 27	10·799471	10·005400	2 1	9·994600	56	59
30	6	9·195527	3 39	10·804473	9·200937	3 40	10·799063	10·005410	3 1	9·994590	54	30
2	8	9·195925	4 52	10·804075	9·201345	4 54	10·798655	10·005420	4 1	9·994580	52	58
30	10	9·196322	5 65	10·803678	9·201752	5 67	10·798248	10·005430	5 2	9·994570	50	30
3	12	9·196719	6 79	10·803281	9·202159	6 81	10·797841	10·005440	6 2	9·994560	48	57
30	14	9·197115	7 92	10·802885	9·202565	7 94	10·797435	10·005450	7 2	9·994550	46	30
4	16	9·197511	8 105	10·802489	9·202971	8 108	10·797029	10·005460	8 3	9·994540	44	56
30	18	9·197907	9 118	10·802093	9·203377	9 121	10·796623	10·005470	9 3	9·994530	42	30
5	20	9·198302	10 131	10·801698	9·203782	10 134	10·796218	10·005481	10 3	9·994519	40	55
30	22	9·198697	11 144	10·801303	9·204188	11 148	10·795812	10·005491	11 4	9·994509	38	30
6	24	9·199091	12 157	10·800909	9·204592	12 161	10·795408	10·005501	12 4	9·994499	36	54
30	26	9·199486	13 170	10·800514	9·204996	13 175	10·795004	10·005511	13 4	9·994489	34	30
7	28	9·199879	14 183	10·800121	9·205400	14 188	10·794600	10·005521	14 5	9·994479	32	53
30	30	9·200273	15 197	10·799727	9·205804	15 201	10·794196	10·005531	15 5	9·994469	30	30
8	32	9·200666	16 210	10·799334	9·206207	16 215	10·793793	10·005541	16 5	9·994459	28	52
30	34	9·201059	17 223	10·798941	9·206610	17 229	10·793390	10·005552	17 6	9·994448	26	30
9	36	9·201451	18 236	10·798549	9·207013	18 242	10·792987	10·005562	18 6	9·994438	24	51
30	38	9·201843	19 249	10·798157	9·207415	19 255	10·792585	10·005572	19 6	9·994428	22	30
10	40	9·202234	20 262	10·797766	9·207817	20 269	10·792183	10·005582	20 7	9·994418	20	50
30	42	9·202626	21 275	10·797374	9·208218	21 282	10·791782	10·005592	21 7	9·994408	18	30
11	44	9·203017	22 288	10·796983	9·208619	22 295	10·791381	10·005602	22 7	9·994398	16	49
30	46	9·203407	23 301	10·796593	9·209020	23 309	10·790980	10·005613	23 8	9·994387	14	30
12	48	9·203797	24 315	10·796203	9·209420	24 323	10·790580	10·005623	24 8	9·994377	12	48
30	50	9·204187	25 328	10·795813	9·209820	25 336	10·790180	10·005633	25 8	9·994367	10	30
13	52	9·204577	26 341	10·795423	9·210220	26 350	10·789780	10·005643	26 9	9·994357	8	47
30	54	9·204966	27 354	10·795034	9·210619	27 363	10·789381	10·005654	27 9	9·994346	6	30
14	56	9·205354	28 367	10·794646	9·211018	28 376	10·788982	10·005664	28 9	9·994336	4	46
30	58	9·205743	29 380	10·794257	9·211417	29 390	10·788583	10·005674	29 10	9·994326	2	30
15	**37**	9·206131	30 393	10·793869	9·211815	30 403	10·788185	10·005684	30 10	9·994316	**23**	45
30	2	9·206519	1 13	10·793481	9·212213	1 13	10·787787	10·005695	1 0	9·994305	58	30
16	4	9·206906	2 25	10·793094	9·212611	2 26	10·787389	10·005705	2 1	9·994295	56	44
30	6	9·207293	3 38	10·792707	9·213008	3 39	10·786992	10·005715	3 1	9·994285	54	30
17	8	9·207679	4 51	10·792321	9·213405	4 52	10·786595	10·005726	4 1	9·994274	52	43
30	10	9·208066	5 64	10·791934	9·213802	5 65	10·786198	10·005736	5 2	9·994264	50	30
18	12	9·208452	6 76	10·791548	9·214198	6 79	10·785802	10·005746	6 2	9·994254	48	42
30	14	9·208837	7 89	10·791163	9·214594	7 92	10·785406	10·005757	7 2	9·994243	46	30
19	16	9·209222	8 102	10·790778	9·214989	8 105	10·785011	10·005767	8 3	9·994233	44	41
30	18	9·209607	9 115	10·790393	9·215385	9 118	10·784615	10·005777	9 3	9·994223	42	30
20	20	9·209992	10 127	10·790008	9·215780	10 131	10·784220	10·005788	10 3	9·994212	40	40
30	22	9·210376	11 140	10·789624	9·216174	11 144	10·783826	10·005798	11 4	9·994202	38	30
21	24	9·210760	12 153	10·789240	9·216568	12 157	10·783432	10·005809	12 4	9·994191	36	39
30	26	9·211143	13 166	10·788857	9·216962	13 170	10·783038	10·005819	13 4	9·994181	34	30
22	28	9·211526	14 178	10·788474	9·217356	14 183	10·782644	10·005829	14 5	9·994171	32	38
30	30	9·211909	15 191	10·788091	9·217749	15 196	10·782251	10·005840	15 5	9·994160	30	30
23	32	9·212291	16 204	10·787709	9·218142	16 210	10·781858	10·005850	16 5	9·994150	28	37
30	34	9·212674	17 217	10·787326	9·218534	17 223	10·781466	10·005861	17 6	9·994139	26	30
24	36	9·213055	18 229	10·786945	9·218926	18 236	10·781074	10·005871	18 6	9·994129	24	36
30	38	9·213437	19 242	10·786563	9·219318	19 249	10·780682	10·005882	19 6	9·994118	22	30
25	40	9·213818	20 255	10·786182	9·219710	20 262	10·780290	10·005892	20 7	9·994108	20	35
30	42	9·214198	21 268	10·785802	9·220101	21 275	10·779899	10·005903	21 7	9·994097	18	30
26	44	9·214579	22 280	10·785421	9·220492	22 288	10·779508	10·005913	22 7	9·994087	16	34
30	46	9·214959	23 293	10·785041	9·220882	23 301	10·779118	10·005924	23 8	9·994076	14	30
27	48	9·215338	24 306	10·784662	9·221272	24 314	10·778728	10·005934	24 8	9·994066	12	33
30	50	9·215718	25 319	10·784282	9·221662	25 327	10·778338	10·005945	25 8	9·994055	10	30
28	52	9·216097	26 331	10·783903	9·222052	26 341	10·777948	10·005955	26 9	9·994045	8	32
30	54	9·216475	27 344	10·783525	9·222441	27 354	10·777559	10·005966	27 9	9·994034	6	30
29	56	9·216854	28 357	10·783146	9·222830	28 367	10·777170	10·005976	28 10	9·994024	4	31
30	58	9·217232	29 370	10·782768	9·223218	29 380	10·776782	10·005987	29 10	9·994013	2	30
30	**38**	9·217609	30 382	10·782391	9·223607	30 393	10·776393	10·005997	30 10	9·994003	0	30
′ ″	m.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m.	′ ″

80° — 5h 22m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 38m					9°							
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·217609		10·782391	9·223607		10·776393	10·005997		9·994003	22	30
30	2	9·217987	1″ 12	10·782013	9·223994	1″ 13	10·776006	10·006008	1″ 0	9·993992	58	30
31	4	9·218363	2 25	10·781637	9·224382	2 25	10·775618	10·006018	2 1	9·993982	56	29
30	6	9·218740	3 37	10·781260	9·224769	3 38	10·775231	10·006029	3 1	9·993971	54	30
32	8	9·219116	4 50	10·780884	9·225156	4 51	10·774844	10·006040	4 1	9·993960	52	28
30	10	9·219492	5 62	10·780508	9·225543	5 64	10·774457	10·006050	5 2	9·993950	50	30
33	12	9·219868	6 74	10·780132	9·225929	6 77	10·774071	10·006061	6 2	9·993939	48	27
30	14	9·220243	7 87	10·779757	9·226315	7 90	10·773685	10·006072	7 2	9·993928	46	30
34	16	9·220618	8 99	10·779382	9·226700	8 102	10·773300	10·006082	8 3	9·993918	44	26
30	18	9·220993	9 112	10·779007	9·227086	9 115	10·772914	10·006093	9 3	9·993907	42	30
35	20	9·221367	10 124	10·778633	9·227471	10 128	10·772529	10·006103	10 4	9·973897	40	25
30	22	9·221741	11 136	10·778259	9·227855	11 140	10·772145	10·006114	11 4	9·993886	38	30
36	24	9·222115	12 149	10·777885	9·228239	12 153	10·771761	10·006125	12 4	9·993875	36	24
30	26	9·222488	13 161	10·777512	9·228623	13 166	10·771377	10·006136	13 5	9·993864	34	30
37	28	9·222861	14 174	10·777139	9·229007	14 179	10·770993	10·006146	14 5	9·993854	32	23
30	30	9·223234	15 186	10·776766	9·229390	15 192	10·770610	10·006157	15 5	9·993843	30	30
38	32	9·223606	16 198	10·776394	9·229773	16 204	10·770227	10·006168	16 6	9·993832	28	22
30	34	9·223978	17 211	10·776022	9·230156	17 217	10·769844	10·006178	17 6	9·993822	26	30
39	36	9·224349	18 223	10·775651	9·230539	18 230	10·769461	10·006189	18 6	9·993811	24	21
30	38	9·224721	19 236	10·775279	9·230921	19 243	10·769079	10·006200	19 7	9·993800	22	30
40	40	9·225092	20 248	10·774908	9·231302	20 255	10·768698	10·006211	20 7	9·993789	20	20
30	42	9·225462	21 261	10·774538	9·231684	21 268	10·768316	10·006221	21 7	9·993779	18	30
41	44	9·225833	22 273	10·774167	9·232065	22 281	10·767935	10·006232	22 8	9·993768	16	19
30	46	9·226203	23 286	10·773797	9·232446	23 294	10·767554	10·006243	23 8	9·993757	14	30
42	48	9·226573	24 298	10·773427	9·232826	24 307	10·767174	10·006254	24 9	9·993746	12	18
30	50	9·226942	25 310	10·773058	9·233206	25 320	10·766794	10·006265	25 9	9·993735	10	30
43	52	9·227311	26 323	10·772689	9·233586	26 332	10·766424	10·006275	26 9	9·993725	8	17
30	54	9·227680	27 335	10·772320	9·233966	27 345	10·766034	10·006286	27 10	9·993714	6	30
44	56	9·228048	28 348	10·771952	9·234345	28 358	10·765655	10·006297	28 10	9·993703	4	16
30	58	9·228416	29 360	10·771584	9·234724	29 371	10·765276	10·006308	29 10	9·993692	2	30
45	39	9·228784	30 372	10·771216	9·235103	30 383	10·764897	10·006319	30 11	9·993681	21	15
30	2	9·229151	1 12	10·770849	9·235481	1 12	10·764519	10·006330	1 0	9·993670	58	30
46	4	9·229518	2 24	10·770482	9·235859	2 25	10·764141	10·006340	2 1	9·993660	56	14
30	6	9·229885	3 36	10·770115	9·236237	3 37	10·763763	10·006351	3 1	9·993649	54	30
47	8	9·230252	4 48	10·769748	9·236614	4 50	10·763386	10·006362	4 1	9·993638	52	13
30	10	9·230618	5 60	10·769382	9·236991	5 62	10·763009	10·006373	5 2	9·993627	50	30
48	12	9·230984	6 73	10·769016	9·237368	6 75	10·762632	10·006384	6 2	9·993616	48	12
30	14	9·231349	7 85	10·768651	9·237744	7 87	10·762256	10·006395	7 3	9·993605	46	30
49	16	9·231715	8 97	10·768285	9·238120	8 100	10·761880	10·006406	8 3	9·993594	44	11
30	18	9·232079	9 109	10·767921	9·238496	9 112	10·761504	10·006417	9 3	9·993583	42	30
50	20	9·232444	10 121	10·767556	9·238872	10 125	10·761128	10·006428	10 4	9·993572	40	10
30	22	9·232808	11 133	10·767192	9·239247	11 137	10·760753	10·006439	11 4	9·993561	38	30
51	24	9·233172	12 145	10·766828	9·239622	12 150	10·760378	10·006450	12 4	9·993550	36	9
30	26	9·233536	13 157	10·766464	9·239996	13 162	10·760004	10·006461	13 5	9·993539	34	30
52	28	9·233899	14 169	10·766101	9·240371	14 175	10·759629	10·006472	14 5	9·993528	32	8
30	30	9·234262	15 181	10·765738	9·240745	15 187	10·759255	10·006483	15 6	9·993517	30	30
53	32	9·234625	16 193	10·765375	9·241118	16 200	10·758882	10·006494	16 6	9·993506	28	7
30	34	9·234987	17 206	10·765013	9·241492	17 212	10·758508	10·006505	17 7	9·993495	26	30
54	36	9·235349	18 218	10·764651	9·241865	18 224	10·758135	10·006516	18 7	9·993484	24	6
30	38	9·235711	19 230	10·764289	9·242238	19 237	10·757762	10·006527	19 7	9·993473	22	30
55	40	9·236073	20 242	10·763927	9·242610	20 249	10·757390	10·006538	20 7	9·993462	20	5
30	42	9·236434	21 254	10·763566	9·242982	21 261	10·757018	10·006549	21 8	9·993451	18	30
56	44	9·236795	22 266	10·763205	9·243354	22 274	10·756646	10·006560	22 8	9·993440	16	4
30	46	9·237155	23 278	10·762845	9·243726	23 286	10·756274	10·006571	23 8	9·993429	14	30
57	48	9·237515	24 290	10·762485	9·244097	24 299	10·755903	10·006582	24 9	9·993418	12	3
30	50	9·237875	25 302	10·762125	9·244468	25 311	10·755532	10·006593	25 9	9·993407	10	30
58	52	9·238235	26 314	10·761765	9·244839	26 323	10·755161	10·006604	26 9	9·993396	8	2
30	54	9·238594	27 327	10·761406	9·245209	27 336	10·754791	10·006615	27 10	9·993385	6	30
59	56	9·238953	28 338	10·761047	9·245579	28 348	10·754421	10·006626	28 10	9·993374	4	1
30	58	9·239312	29 351	10·760688	9·245949	29 361	10·754051	10·006637	29 11	9·993363	2	30
60	40	9·230670	30 363	10·760330	9·246319	30 374	10·753681	10·006649	30 11	9·993351	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
					80°						5h 20m	

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 40m — 10°

′ ″	m.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m.	′ ″
0	0	9·239670		10·760330	9·246319		10·753681	10·006649		9·993351	20	60
30	2	9·240028	1″ 12	10·759972	9·246688	1″ 12	10·753312	10·006660	1″ 0	9·993340	58	30
1	4	9·240386	2 24	10·759614	9·247057	2 24	10·752943	10·006671	2 1	9·993329	56	59
30	6	9·240744	3 35	10·759256	9·247426	3 36	10·752574	10·006682	3 1	9·993318	54	30
2	8	9·241101	4 47	10·758899	9·247794	4 49	10·752206	10·006693	4 2	9·993307	52	58
30	10	9·241458	5 59	10·758542	9·248162	5 61	10·751838	10·006704	5 2	9·993296	50	30
3	12	9·241814	6 71	10·758186	9·248530	6 73	10·751470	10·006716	6 2	9·993284	48	57
30	14	9·242170	7 83	10·757830	9·248897	7 85	10·751103	10·006727	7 3	9·993273	46	30
4	16	9·242526	8 94	10·757474	9·249264	8 97	10·750736	10·006738	8 3	9·993262	44	56
30	18	9·242882	9 106	10·757118	9·249631	9 110	10·750369	10·006749	9 3	9·993251	42	30
5	20	9·243237	10 118	10·756763	9·249998	10 122	10·750002	10·006760	10 4	9·993240	40	55
30	22	9·243592	11 130	10·756408	9·250364	11 134	10·749636	10·006772	11 4	9·993228	38	30
6	24	9·243947	12 141	10·756053	9·250730	12 146	10·749270	10·006783	12 5	9·993217	36	54
30	26	9·244302	13 153	10·755698	9·251096	13 158	10·748904	10·006794	13 5	9·993206	34	30
7	28	9·244656	14 165	10·755344	9·251461	14 170	10·748539	10·006805	14 5	9·993195	32	53
30	30	9·245010	15 177	10·754990	9·251826	15 183	10·748174	10·006817	15 6	9·993183	30	30
8	32	9·245363	16 189	10·754637	9·252191	16 195	10·747809	10·006828	16 6	9·993172	28	52
30	34	9·245717	17 200	10·754283	9·252556	17 207	10·747444	10·006839	17 6	9·993161	26	30
9	36	9·246069	18 212	10·753931	9·252920	18 219	10·747080	10·006851	18 7	9·993149	24	51
30	38	9·246422	19 224	10·753578	9·253284	19 231	10·746716	10·006862	19 7	9·993138	22	30
10	40	9·246775	20 236	10·753225	9·253648	20 243	10·746352	10·006873	20 8	9·993127	20	50
30	42	9·247127	21 248	10·752873	9·254011	21 256	10·745989	10·006885	21 8	9·993115	18	30
11	44	9·247478	22 259	10·752522	9·254374	22 268	10·745626	10·006896	22 8	9·993104	16	49
30	46	9·247830	23 271	10·752170	9·254737	23 280	10·745263	10·006907	23 9	9·993093	14	30
12	48	9·248181	24 283	10·751819	9·255100	24 292	10·744900	10·006919	24 9	9·993081	12	48
30	50	9·248532	25 295	10·751468	9·255462	25 304	10·744538	10·006930	25 9	9·993070	10	30
13	52	9·248883	26 307	10·751117	9·255824	26 316	10·744176	10·006941	26 10	9·993059	8	47
30	54	9·249233	27 318	10·750767	9·256186	27 329	10·743814	10·006953	27 10	9·993047	6	30
14	56	9·249583	28 330	10·750417	9·256547	28 341	10·743453	10·006964	28 11	9·993036	4	46
30	58	9·249933	29 342	10·750067	9·256908	29 353	10·743092	10·006976	29 11	9·993024	2	30
15	**41**	9·250282	30 354	10·749718	9·257269	30 365	10·742731	10·006987	30 11	9·993013	**19**	45
30	2	9·250631	1″ 11	10·749369	9·257630	1 12	10·742370	10·006998	1 0	9·993002	58	30
16	4	9·250980	2 23	10·749020	9·257990	2 24	10·742010	10·007010	2 1	9·992990	56	44
30	6	9·251329	3 34	10·748671	9·258350	3 36	10·741650	10·007021	3 1	9·992979	54	30
17	8	9·251677	4 46	10·748323	9·258710	4 48	10·741290	10·007033	4 2	9·992967	52	43
30	10	9·252025	5 57	10·747975	9·259069	5 59	10·740931	10·007044	5 2	9·992956	50	30
18	12	9·252373	6 69	10·747627	9·259429	6 71	10·740571	10·007056	6 2	9·992944	48	42
30	14	9·252720	7 80	10·747280	9·259787	7 83	10·740213	10·007067	7 3	9·992933	46	30
19	16	9·253067	8 92	10·746933	9·260146	8 95	10·739854	10·007079	8 3	9·992921	44	41
30	18	9·253414	9 103	10·746586	9·260504	9 107	10·739496	10·007090	9 3	9·992910	42	30
20	20	9·253761	10 115	10·746239	9·260863	10 119	10·739137	10·007102	10 4	9·992898	40	40
30	22	9·254107	11 126	10·745893	9·261220	11 131	10·738780	10·007113	11 4	9·992887	38	30
21	24	9·254453	12 138	10·745547	9·261578	12 143	10·738422	10·007125	12 5	9·992875	36	39
30	26	9·254799	13 149	10·745201	9·261935	13 155	10·738065	10·007136	13 5	9·992864	34	30
22	28	9·255144	14 161	10·744856	9·262292	14 167	10·737708	10·007148	14 5	9·992852	32	38
30	30	9·255490	15 172	10·744510	9·262649	15 178	10·737351	10·007159	15 6	9·992841	30	30
23	32	9·255834	16 184	10·744166	9·263005	16 190	10·736995	10·007171	16 6	9·992829	28	37
30	34	9·256179	17 195	10·743821	9·263361	17 202	10·736639	10·007182	17 6	9·992818	26	30
24	36	9·256523	18 207	10·743477	9·263717	18 214	10·736283	10·007194	18 7	9·992806	24	36
30	38	9·256867	19 218	10·743133	9·264073	19 226	10·735927	10·007206	19 7	9·992794	22	30
25	40	9·257211	20 230	10·742789	9·264428	20 238	10·735572	10·007217	20 8	9·992783	20	35
30	42	9·257554	21 241	10·742446	9·264783	21 250	10·735217	10·007229	21 8	9·992771	18	30
26	44	9·257898	22 253	10·742102	9·265138	22 262	10·734862	10·007241	22 8	9·992759	16	34
30	46	9·258241	23 264	10·741759	9·265493	23 274	10·734507	10·007252	23 9	9·992748	14	30
27	48	9·258583	24 276	10·741417	9·265847	24 285	10·734153	10·007265	24 9	9·992736	12	33
30	50	9·258926	25 287	10·741074	9·266201	25 297	10·733799	10·007276	25 10	9·992724	10	30
28	52	9·259268	26 299	10·740732	9·266555	26 309	10·733445	10·007287	26 10	9·992713	8	32
30	54	9·259609	27 310	10·740391	9·266908	27 321	10·733092	10·007299	27 10	9·992701	6	30
29	56	9·259951	28 322	10·740049	9·267261	28 333	10·732739	10·007310	28 11	9·992690	4	31
30	58	9·260292	29 333	10·739708	9·267614	29 345	10·732386	10·007322	29 11	9·992678	2	30
30	**42**	9·260633	30 345	10·739367	9·267967	30 357	10·732033	10·007334	30 12	9·992666	0	30
′ ″	m.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m.	′ ″

79° — 5h 18m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

$0^h\ 42^m$ — 10°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·260633		10·739367	9·267967		10·732033	10·007334		9·992666	[illegible]	30
30	2	9·260974	1″ 11	10·739026	9·268319	1″ 12	10·731681	10·007346	1″ 0	9·992654	58	30
31	4	9·261314	2 22	10·738686	9·268671	2 23	10·731329	10·007357	2 1	9·992643	56	29
30	6	9·261654	3 34	10·738346	9·269023	3 35	10·730977	10·007369	3 1	9·992631	54	30
32	8	9·261994	4 45	10·738006	9·269375	4 46	10·730625	10·007381	4 2	9·992619	52	28
30	10	9·262334	5 56	10·737666	9·269726	5 58	10·730274	10·007393	5 2	9·992607	50	30
33	12	9·262673	6 67	10·737327	9·270077	6 70	10·729923	10·007404	6 2	9·992596	48	27
30	14	9·263012	7 78	10·736988	9·270428	7 81	10·729572	10·007416	7 3	9·992584	46	30
34	16	9·263351	8 90	10·736649	9·270779	8 93	10·729221	10·007428	8 3	9·992572	44	26
30	18	9·263689	9 101	10·736311	9·271129	9 105	10·728871	10·007440	9 4	9·992560	42	30
35	20	9·264027	10 112	10·735973	9·271479	10 116	10·728521	10·007451	10 4	9·992549	40	25
30	22	9·264365	11 123	10·735635	9·271829	11 128	10·728171	10·007463	11 4	9·992537	38	30
36	24	9·264703	12 135	10·735297	9·272178	12 139	10·727822	10·007475	12 5	9·992525	36	24
30	26	9·265040	13 146	10·734960	9·272527	13 151	10·727473	10·007487	13 5	9·992513	34	30
37	28	9·265377	14 157	10·734623	9·272876	14 162	10·727124	10·007499	14 6	9·992501	32	23
30	30	9·265714	15 168	10·734286	9·273225	15 174	10·726775	10·007511	15 6	9·992489	30	30
38	32	9·266051	16 179	10·733949	9·273573	16 186	10·726427	10·007522	16 6	9·992478	28	22
30	34	9·266387	17 191	10·733613	9·273921	17 197	10·726079	10·007534	17 7	9·992466	26	30
39	36	9·266723	18 202	10·733277	9·274269	18 209	10·725731	10·007546	18 7	9·992454	24	21
30	38	9·267059	19 213	10·732941	9·274617	19 221	10·725383	10·007558	19 7	9·992442	22	30
40	40	9·267395	20 224	10·732605	9·274964	20 232	10·725036	10·007570	20 8	9·992430	20	20
30	42	9·267730	21 236	10·732270	9·275312	21 244	10·724688	10·007582	21 8	9·992418	18	30
41	44	9·268065	22 247	10·731935	9·275658	22 256	10·724342	10·007594	22 9	9·992406	16	19
30	46	9·268399	23 258	10·731601	9·276005	23 267	10·723995	10·007606	23 9	9·992394	14	30
42	48	9·268734	24 269	10·731266	9·276351	24 279	10·723649	10·007618	24 9	9·992382	12	18
30	50	9·269068	25 280	10·730932	9·276698	25 290	10·723302	10·007630	25 10	9·992370	10	30
43	52	9·269402	26 292	10·730598	9·277043	26 302	10·722957	10·007641	26 10	9·992359	8	17
30	54	9·269736	27 303	10·730264	9·277389	27 314	10·722611	10·007653	27 11	9·992347	6	30
44	56	9·270069	28 315	10·729931	9·277734	28 325	10·722266	10·007665	28 11	9·992335	4	16
30	58	9·270402	29 326	10·729598	9·278079	29 337	10·721921	10·007677	29 11	9·992323	2	30
45	[illegible]	9·270735	30 337	10·729265	9·278424	30 349	10·721576	10·007689	30 12	9·992311	27	15
30	2	9·271067	1 11	10·728933	9·278769	1 11	10·721231	10·007701	1 0	9·992299	58	30
46	4	9·271400	2 22	10·728600	9·279113	2 23	10·720887	10·007713	2 1	9·992287	56	14
30	6	9·271732	3 33	10·728268	9·279457	3 34	10·720543	10·007725	3 1	9·992275	54	30
47	8	9·272064	4 44	10·727936	9·279801	4 45	10·720199	10·007737	4 2	9·992263	52	13
30	10	9·272395	5 55	10·727605	9·280144	5 57	10·719856	10·007749	5 2	9·992251	50	30
48	12	9·272726	6 66	10·727274	9·280488	6 68	10·719512	10·007761	6 2	9·992239	48	12
30	14	9·273057	7 77	10·726943	9·280831	7 79	10·719169	10·007774	7 3	9·992226	46	30
49	16	9·273388	8 88	10·726612	9·281174	8 91	10·718826	10·007786	8 3	9·992214	44	11
30	18	9·273718	9 99	10·726282	9·281516	9 102	10·718484	10·007798	9 4	9·992202	42	30
50	20	9·274049	10 110	10·725951	9·281858	10 114	10·718142	10·007810	10 4	9·992190	40	10
30	22	9·274379	11 121	10·725621	9·282201	11 125	10·717799	10·007822	11 4	9·992178	38	30
51	24	9·274708	12 132	10·725292	9·282542	12 136	10·717458	10·007834	12 5	9·992166	36	9
30	26	9·275038	13 142	10·724962	9·282884	13 148	10·717116	10·007846	13 5	9·992154	34	30
52	28	9·275367	14 153	10·724633	9·283225	14 159	10·716775	10·007858	14 6	9·992142	32	8
30	30	9·275696	15 164	10·724304	9·283566	15 170	10·716434	10·007870	15 6	9·992130	30	30
53	32	9·276025	16 175	10·723975	9·283907	16 182	10·716093	10·007882	16 6	9·992118	28	7
30	34	9·276353	17 186	10·723647	9·284248	17 193	10·715752	10·007895	17 7	9·992105	26	30
54	36	9·276681	18 197	10·723319	9·284588	18 205	10·715412	10·007907	18 7	9·992093	24	6
30	38	9·277009	19 208	10·722991	9·284928	19 216	10·715072	10·007919	19 8	9·992081	22	30
55	40	9·277337	20 219	10·722663	9·285268	20 227	10·714732	10·007931	20 8	9·992069	20	5
30	42	9·277664	21 230	10·722336	9·285607	21 239	10·714393	10·007943	21 8	9·992057	18	30
56	44	9·277991	22 241	10·722009	9·285947	22 250	10·714053	10·007956	22 9	9·992044	16	4
30	46	9·278318	23 252	10·721682	9·286286	23 261	10·713714	10·007968	23 9	9·992032	14	30
57	48	9·278645	24 263	10·721355	9·286624	24 273	10·713376	10·007980	24 10	9·992020	12	3
30	50	9·278971	25 274	10·721029	9·286963	25 284	10·713037	10·007992	25 10	9·992008	10	30
58	52	9·279297	26 285	10·720703	9·287301	26 295	10·712699	10·008004	26 10	9·991996	8	2
30	54	9·279623	27 296	10·720377	9·287639	27 307	10·712361	10·008017	27 11	9·991983	6	30
59	56	9·279948	28 307	10·720052	9·287977	28 318	10·712023	10·008029	28 11	9·991971	4	1
30	58	9·280274	29 318	10·719726	9·288315	29 330	10·711685	10·008041	29 12	9·991959	2	30
60	[illegible]	9·280599	30 329	10·719401	9·288652	30 341	10·711348	10·008053	30 12	9·991947	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

79° — $5^h\ 16^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0ʰ 44ᵐ 11°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·280599		10·719401	9·288652		10·711348	10·008053		9·991947	16	60
30	2	9·280924	1″ 11	10·719076	9·288989	1″ 11	10·711011	10·008066	1″ 0	9·991934	58	30
1	4	9·281248	2 21	10·718752	9·289326	2 22	10·710674	10·008078	2 1	9·991922	56	59
30	6	9·281573	3 32	10·718427	9·289663	3 33	10·710337	10·008090	3 1	9·991910	54	30
2	8	9·281897	4 43	10·718103	9·289999	4 44	10·710001	10·008103	4 2	9·991897	52	58
30	10	9·282220	5 53	10·717780	9·290335	5 56	10·709665	10·008115	5 2	9·991885	50	30
3	12	9·282544	6 64	10·717456	9·290671	6 67	10·709329	10·008127	6 2	9·991873	48	57
30	14	9·282867	7 75	10·717133	9·291007	7 78	10·708993	10·008140	7 3	9·991860	46	30
4	16	9·283190	8 86	10·716810	9·291342	8 89	10·708658	10·008152	8 3	9·991848	44	56
30	18	9·283513	9 96	10·716487	9·291678	9 100	10·708322	10·008164	9 4	9·991836	42	30
5	20	9·283836	10 107	10·716164	9·292013	10 111	10·707987	10·008177	10 4	9·991823	40	55
30	22	9·284158	11 118	10·715842	9·292347	11 122	10·707653	10·008189	11 5	9·991811	38	30
6	24	9·284480	12 128	10·715520	9·292682	12 133	10·707318	10·008201	12 5	9·991799	36	54
30	26	9·284802	13 139	10·715198	9·293016	13 145	10·706984	10·008214	13 5	9·991786	34	30
7	28	9·285124	14 150	10·714876	9·293350	14 156	10·706650	10·008226	14 6	9·991774	32	53
30	30	9·285445	15 160	10·714555	9·293684	15 167	10·706316	10·008239	15 6	9·991761	30	30
8	32	9·285766	16 171	10·714234	9·294017	16 178	10·705983	10·008251	16 7	9·991749	28	52
30	34	9·286087	17 182	10·713913	9·294351	17 189	10·705649	10·008264	17 7	9·991736	26	30
9	36	9·286408	18 193	10·713592	9·294684	18 200	10·705316	10·008276	18 7	9·991724	24	51
30	38	9·286728	19 203	10·713272	9·295016	19 211	10·704984	10·008288	19 8	9·991712	22	30
10	40	9·287048	20 214	10·712952	9·295349	20 222	10·704651	10·008301	20 8	9·991699	20	50
30	42	9·287368	21 225	10·712632	9·295681	21 233	10·704319	10·008313	21 9	9·991687	18	30
11	44	9·287688	22 235	10·712312	9·296013	22 245	10·703987	10·008326	22 9	9·991674	16	49
30	46	9·288007	23 246	10·711993	9·296345	23 256	10·703655	10·008338	23 10	9·991662	14	30
12	48	9·288326	24 257	10·711674	9·296677	24 267	10·703323	10·008351	24 10	9·991649	12	48
30	50	9·288645	25 267	10·711355	9·297008	25 278	10·702992	10·008363	25 10	9·991637	10	30
13	52	9·288964	26 278	10·711036	9·297339	26 289	10·702661	10·008376	26 11	9·991624	8	47
30	54	9·289282	27 289	10·710718	9·297670	27 300	10·702330	10·008388	27 11	9·991612	6	30
14	56	9·289600	28 300	10·710400	9·298001	28 311	10·701999	10·008401	28 12	9·991599	4	46
30	58	9·289918	29 310	10·710082	9·298332	29 322	10·701668	10·008414	29 12	9·991586	2	30
15	45	9·290236	30 321	10·709764	9·298662	30 334	10·701338	10·008426	30 12	9·991574	15	45
30	2	9·290553	1 10	10·709447	9·298992	1 11	10·701008	10·008439	1 0	9·991561	58	30
16	4	9·290870	2 21	10·709130	9·299322	2 22	10·700678	10·008451	2 1	9·991549	56	44
30	6	9·291187	3 31	10·708813	9·299651	3 33	10·700349	10·008464	3 1	9·991536	54	30
17	8	9·291504	4 42	10·708496	9·299980	4 44	10·700020	10·008476	4 2	9·991524	52	43
30	10	9·291820	5 52	10·708180	9·300309	5 54	10·699691	10·008489	5 2	9·991511	50	30
18	12	9·292137	6 63	10·707863	9·300638	6 65	10·699362	10·008502	6 3	9·991498	48	42
30	14	9·292453	7 73	10·707547	9·300967	7 76	10·699033	10·008514	7 3	9·991486	46	30
19	16	9·292768	8 84	10·707232	9·301295	8 87	10·698705	10·008527	8 3	9·991473	44	41
30	18	9·293084	9 94	10·706916	9·301624	9 98	10·698376	10·008540	9 4	9·991460	42	30
20	20	9·293399	10 105	10·706601	9·301951	10 109	10·698049	10·008552	10 4	9·991448	40	40
30	22	9·293714	11 115	10·706286	9·302279	11 120	10·697721	10·008565	11 5	9·991435	38	30
21	24	9·294029	12 126	10·705971	9·302607	12 131	10·697393	10·008578	12 5	9·991422	36	39
30	26	9·294344	13 136	10·705656	9·302934	13 142	10·697066	10·008590	13 6	9·991410	34	30
22	28	9·294658	14 147	10·705342	9·303261	14 153	10·696739	10·008603	14 6	9·991397	32	38
30	30	9·294972	15 157	10·705028	9·303588	15 163	10·696412	10·008616	15 6	9·991384	30	30
23	32	9·295286	16 168	10·704714	9·303914	16 174	10·696086	10·008628	16 7	9·991372	28	37
30	34	9·295600	17 178	10·704400	9·304241	17 185	10·695759	10·008641	17 7	9·991359	26	30
24	36	9·295913	18 188	10·704087	9·304567	18 196	10·695433	10·008654	18 8	9·991346	24	36
30	38	9·296226	19 199	10·703774	9·304893	19 207	10·695107	10·008667	19 8	9·991333	22	30
25	40	9·296539	20 209	10·703461	9·305218	20 218	10·694782	10·008679	20 8	9·991321	20	35
30	42	9·296852	21 220	10·703148	9·305544	21 229	10·694456	10·008692	21 9	9·991308	18	30
26	44	9·297164	22 230	10·702836	9·305869	22 240	10·694131	10·008705	22 9	9·991295	16	34
30	46	9·297476	23 241	10·702524	9·306194	23 251	10·693806	10·008718	23 10	9·991282	14	30
27	48	9·297788	24 251	10·702212	9·306519	24 262	10·693481	10·008730	24 10	9·991270	12	33
30	50	9·298100	25 262	10·701900	9·306843	25 272	10·693157	10·008743	25 11	9·991257	10	30
28	52	9·298412	26 272	10·701588	9·307168	26 283	10·692832	10·008756	26 11	9·991244	8	32
30	54	9·298723	27 283	10·701277	9·307492	27 294	10·692508	10·008769	27 11	9·991231	6	30
29	56	9·299034	28 293	10·700966	9·307816	28 305	10·692184	10·008782	28 12	9·991218	4	31
30	58	9·299345	29 304	10·700655	9·308139	29 316	10·691861	10·008794	29 12	9·991206	2	30
30	46	9·299655	30 314	10·700345	9·308463	30 327	10·691537	10·008807	30 13	9·991193	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

78° 5ʰ 14ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES. COSINES, &c.

$0^h\ 46^m$ 11°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·299655		10·700345	9·308463		10·691537	10·008807		9·991193	14	30
30	2	9·299966	1″ 10	10·700034	9·308786	1″ 11	10·691214	10·008820	1″ 0	9·991180	58	30
31	4	9·300276	2 21	10·699724	9·309109	2 21	10·690891	10·008833	2 1	9·991167	56	29
30	6	9·300586	3 31	10·699414	9·309432	3 32	10·690568	10·008846	3 1	9·991154	54	30
32	8	9·300895	4 41	10·699105	9·309754	4 43	10·690246	10·008859	4 2	9·991141	52	28
30	10	9·301205	5 51	10·698795	9·310076	5 53	10·689924	10·008872	5 2	9·991128	50	30
33	12	9·301514	6 61	10·698486	9·310399	6 64	10·689601	10·008885	6 3	9·991115	48	27
30	14	9·301823	7 71	10·698177	9·310720	7 75	10·689280	10·008897	7 3	9·991103	46	30
34	16	9·302132	8 82	10·697868	9·311042	8 85	10·688958	10·008910	8 3	9·991090	44	26
30	18	9·302440	9 92	10·697560	9·311364	9 96	10·688636	10·008923	9 4	9·991077	42	30
35	20	9·302748	10 102	10·697252	9·311685	10 107	10·688315	10·008936	10 4	9·991064	40	25
30	22	9·303057	11 113	10·696943	9·312006	11 117	10·687994	10·008949	11 5	9·991051	38	30
36	24	9·303364	12 123	10·696636	9·312327	12 128	10·687673	10·008962	12 5	9·991038	36	24
30	26	9·303672	13 133	10·696328	9·312647	13 139	10·687353	10·008975	13 6	9·991025	34	30
37	28	9·303979	14 143	10·696021	9·312968	14 149	10·687032	10·008988	14 6	9·991012	32	23
30	30	9·304287	15 153	10·695713	9·313288	15 160	10·686712	10·009001	15 6	9·990999	30	30
38	32	9·304593	16 164	10·695407	9·313608	16 171	10·686392	10·009014	16 7	9·990986	28	22
30	34	9·304900	17 174	10·695100	9·313927	17 181	10·686073	10·009027	17 7	9·990973	26	30
39	36	9·305207	18 184	10·694793	9·314247	18 192	10·685753	10·009040	18 8	9·990960	24	21
30	38	9·305513	19 194	10·694487	9·314566	19 203	10·685434	10·009053	19 8	9·990947	22	30
40	40	9·305819	20 205	10·694181	9·314885	20 213	10·685115	10·009066	20 9	9·990934	20	20
30	42	9·306125	21 215	10·693875	9·315204	21 224	10·684796	10·009079	21 9	9·990921	18	30
41	44	9·306430	22 225	10·693570	9·315523	22 235	10·684477	10·009092	22 10	9·990908	16	19
30	46	9·306736	23 235	10·693264	9·315841	23 245	10·684159	10·009105	23 10	9·990895	14	30
42	48	9·307041	24 245	10·692959	9·316159	24 256	10·683841	10·009118	24 10	9·990882	12	18
30	50	9·307346	25 256	10·692654	9·316477	25 267	10·683523	10·009132	25 11	9·990868	10	30
43	52	9·307650	26 266	10·692350	9·316795	26 277	10·683205	10·009145	26 11	9·990855	8	17
30	54	9·307955	27 276	10·692045	9·317113	27 288	10·682887	10·009158	27 12	9·990842	6	30
44	56	9·308259	28 286	10·691741	9·317430	28 299	10·682570	10·009171	28 12	9·990829	4	16
30	58	9·308563	29 297	10·691437	9·317747	29 309	10·682253	10·009184	29 13	9·990816	2	30
45	47	9·308867	30 307	10·691133	9·318064	30 320	10·681936	10·009197	30 13	9·990803	13	15
30	2	9·309170	1 10	10·690830	9·318381	1 10	10·681619	10·009210	1 0	9·990790	58	30
46	4	9·309474	2 20	10·690526	9·318697	2 21	10·681303	10·009223	2 1	9·990777	56	14
30	6	9·309777	3 30	10·690223	9·319013	3 31	10·680987	10·009237	3 1	9·990763	54	30
47	8	9·310080	4 40	10·689920	9·319330	4 42	10·680670	10·009250	4 2	9·990750	52	13
30	10	9·310382	5 50	10·689618	9·319645	5 52	10·680355	10·009263	5 2	9·990737	50	30
48	12	9·310685	6 60	10·689315	9·319961	6 63	10·680039	10·009276	6 3	9·990724	48	12
30	14	9·310987	7 70	10·689013	9·320277	7 73	10·679723	10·009289	7 3	9·990711	46	30
49	16	9·311289	8 80	10·688711	9·320592	8 84	10·679408	10·009303	8 4	9·990697	44	11
30	18	9·311591	9 90	10·688409	9·320907	9 94	10·679093	10·009316	9 4	9·990684	42	30
50	20	9·311893	10 100	10·688107	9·321222	10 104	10·678778	10·009329	10 4	9·990671	40	10
30	22	9·312194	11 110	10·687806	9·321536	11 115	10·678464	10·009342	11 5	9·990658	38	30
51	24	9·312495	12 120	10·687505	9·321851	12 125	10·678149	10·009355	12 5	9·990645	36	9
30	26	9·312796	13 130	10·687204	9·322165	13 136	10·677835	10·009369	13 6	9·990631	34	30
52	28	9·313097	14 140	10·686903	9·322479	14 146	10·677521	10·009382	14 6	9·990618	32	8
30	30	9·313397	15 150	10·686603	9·322793	15 157	10·677207	10·009395	15 7	9·990605	30	30
53	32	9·313698	16 160	10·686302	9·323106	16 167	10·676894	10·009409	16 7	9·990591	28	7
30	34	9·313998	17 170	10·686002	9·323420	17 178	10·676580	10·009422	17 8	9·990578	26	30
54	36	9·314297	18 180	10·685703	9·323733	18 188	10·676267	10·009435	18 8	9·990565	24	6
30	38	9·314597	19 190	10·685403	9·324046	19 199	10·675954	10·009449	19 8	9·990552	22	30
55	40	9·314897	20 200	10·685103	9·324358	20 209	10·675642	10·009462	20 9	9·990538	20	5
30	42	9·315196	21 210	10·684804	9·324671	21 219	10·675329	10·009475	21 9	9·990525	18	30
56	44	9·315495	22 220	10·684505	9·324983	22 230	10·675017	10·009489	22 10	9·990511	16	4
30	46	9·315793	23 230	10·684207	9·325295	23 240	10·674705	10·009502	23 10	9·990498	14	30
57	48	9·316092	24 240	10·683908	9·325607	24 251	10·674393	10·009515	24 11	9·990485	12	3
30	50	9·316390	25 250	10·683610	9·325919	25 261	10·674081	10·009529	25 11	9·990471	10	30
58	52	9·316689	26 260	10·683311	9·326231	26 272	10·673769	10·009542	26 12	9·990458	8	2
30	54	9·316986	27 270	10·683014	9·326542	27 282	10·673458	10·009555	27 12	9·990445	6	30
59	56	9·317284	28 280	10·682716	9·326853	28 293	10·673147	10·009569	28 12	9·990431	4	1
30	58	9·317582	29 290	10·682418	9·327164	29 303	10·672836	10·009582	29 13	9·990418	2	30
60	48	9·317879	30 300	10·682121	9·327475	30 313	10·672525	10·009596	30 13	9·990404	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

78° $5^h\ 12^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0ʰ 48ᵐ — 12°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·317879		10·682121	9·327475		10·672525	10·009596		9·990404	12	60
30	2	9·318176	1″ 10	10·681824	9·327785	1″ 10	10·672215	10·009609	1″ 0	9·990391	58	30
1	4	9·318473	2 20	10·681527	9·328095	2 20	10·671905	10·009622	2 1	9·990378	56	59
30	6	9·318769	3 29	10·681231	9·328405	3 31	10·671595	10·009636	4 1	9·990364	54	30
2	8	9·319066	4 39	10·680934	9·328715	4 41	10·671285	10·009649	4 2	9·990351	52	58
30	10	9·319362	5 49	10·680638	9·329025	5 51	10·670975	10·009663	5 2	9·990337	50	30
3	12	9·319658	6 59	10·680342	9·329334	6 61	10·670666	10·009676	6 3	9·990324	48	57
30	14	9·319954	7 69	10·680046	9·329644	7 72	10·670356	10·009690	7 3	9·990310	46	30
4	16	9·320249	8 78	10·679751	9·329953	8 82	10·670047	10·009703	8 4	9·990297	44	56
30	18	9·320545	9 88	10·679455	9·330262	9 92	10·669738	10·009717	9 4	9·990283	42	30
5	20	9·320840	10 98	10·679160	9·330570	10 102	10·669430	10·009730	10 5	9·990270	40	55
30	22	9·321135	11 108	10·678865	9·330879	11 113	10·669121	10·009744	11 5	9·990256	38	30
6	24	9·321430	12 118	10·678570	9·331187	12 123	10·668813	10·009757	12 5	9·990243	36	54
30	26	9·321724	13 127	10·678276	9·331495	13 133	10·668505	10·009771	13 6	9·990229	34	30
7	28	9·322019	14 137	10·677981	9·331803	14 143	10·668197	10·009785	14 6	9·990215	32	53
30	30	9·322313	15 147	10·677687	9·332111	15 154	10·667889	10·009798	15 7	9·990202	30	30
8	32	9·322607	16 157	10·677393	9·332418	16 164	10·667582	10·009812	16 7	9·990188	28	52
30	34	9·322900	17 167	10·677100	9·332726	17 174	10·667274	10·009825	17 8	9·990175	26	30
9	36	9·323194	18 176	10·676806	9·333033	18 184	10·666967	10·009839	18 8	9·990161	24	51
30	38	9·323487	19 186	10·676513	9·333340	19 195	10·666660	10·009852	19 9	9·990148	22	30
10	40	9·323780	20 196	10·676220	9·333646	20 205	10·666354	10·009866	20 9	9·990134	20	50
30	42	9·324073	21 206	10·675927	9·333953	21 215	10·666047	10·009880	21 9	9·990120	18	30
11	44	9·324366	22 216	10·675634	9·334259	22 225	10·665741	10·009893	22 10	9·990107	16	49
30	46	9·324658	23 225	10·675342	9·334565	23 236	10·665435	10·009907	23 10	9·990093	14	30
12	48	9·324950	24 235	10·675050	9·334871	24 246	10·665129	10·009921	24 11	9·990079	12	48
30	50	9·325243	25 245	10·674757	9·335177	25 256	10·664823	10·009934	25 11	9·990066	10	30
13	52	9·325534	26 255	10·674466	9·335482	26 266	10·664518	10·009948	26 12	9·990052	8	47
30	54	9·325826	27 265	10·674174	9·335788	27 277	10·664212	10·009962	27 12	9·990038	6	30
14	56	9·326117	28 274	10·673883	9·336093	28 287	10·663907	10·009975	28 13	9·990025	4	46
30	58	9·326409	29 284	10·673591	9·336398	29 297	10·663602	10·009989	29 13	9·990011	2	30
15	49	9·326700	30 294	10·673300	9·336702	30 307	10·663298	10·010003	30 14	9·989997	11	45
30	2	9·326991	1 10	10·673009	9·337007	1 10	10·662993	10·010016	1 0	9·989984	58	30
16	4	9·327281	2 19	10·672719	9·337311	2 20	10·662689	10·010030	2 1	9·989970	56	44
30	6	9·327572	3 29	10·672428	9·337615	3 30	10·662385	10·010044	3 1	9·989956	54	30
17	8	9·327862	4 38	10·672138	9·337919	4 40	10·662081	10·010058	4 2	9·989942	52	43
30	10	9·328152	5 48	10·671848	9·338223	5 50	10·661777	10·010071	5 2	9·989929	50	30
18	12	9·328442	6 58	10·671558	9·338527	6 60	10·661473	10·010085	6 3	9·989915	48	42
30	14	9·328731	7 67	10·671269	9·338830	7 70	10·661170	10·010099	7 3	9·989901	46	30
19	16	9·329021	8 77	10·670979	9·339133	8 80	10·660867	10·010113	8 4	9·989887	44	41
30	18	9·329310	9 86	10·670690	9·339436	9 90	10·660564	10·010127	9 4	9·989873	42	30
20	20	9·329599	10 96	10·670401	9·339739	10 101	10·660261	10·010140	10 5	9·989860	40	40
30	22	9·329888	11 106	10·670112	9·340042	11 111	10·659958	10·010154	11 5	9·989846	38	30
21	24	9·330176	12 115	10·669824	9·340344	12 121	10·659656	10·010168	12 5	9·989832	36	39
30	26	9·330465	13 125	10·669535	9·340646	13 131	10·659354	10·010182	13 6	9·989818	34	30
22	28	9·330753	14 134	10·669247	9·340948	14 141	10·659052	10·010196	14 6	9·989804	32	38
30	30	9·331041	15 144	10·668959	9·341250	15 151	10·658750	10·010210	15 7	9·989790	30	30
23	32	9·331320	16 154	10·668671	9·341552	16 161	10·658448	10·010223	16 7	9·989777	28	37
30	34	9·331616	17 163	10·668384	9·341853	17 171	10·658147	10·010237	17 8	9·989763	26	30
24	36	9·331903	18 173	10·668097	9·342155	18 181	10·657845	10·010251	18 8	9·989749	24	36
30	38	9·332191	19 182	10·667809	9·342456	19 191	10·657544	10·010265	19 9	9·989735	22	30
25	40	9·332478	20 192	10·667522	9·342757	20 201	10·657243	10·010279	20 9	9·989721	20	35
30	42	9·332764	21 202	10·667236	9·343057	21 211	10·656943	10·010293	21 9	9·989707	18	30
26	44	9·333051	22 211	10·666949	9·343358	22 221	10·656642	10·010307	22 10	9·989693	16	34
30	46	9·333337	23 221	10·666663	9·343658	23 231	10·656342	10·010321	23 10	9·989679	14	30
27	48	9·333624	24 230	10·666376	9·343958	24 241	10·656042	10·010335	24 11	9·989665	12	33
30	50	9·333910	25 240	10·666090	9·344258	25 252	10·655742	10·010349	25 11	9·989651	10	30
28	52	9·334195	26 250	10·665805	9·344558	26 262	10·655442	10·010363	26 12	9·989637	8	32
30	54	9·334481	27 259	10·665519	9·344858	27 272	10·655142	10·010377	27 12	9·989623	6	30
29	56	9·334767	28 269	10·665233	9·345157	28 282	10·654843	10·010390	28 13	9·989610	4	31
30	58	9·335052	29 278	10·664948	9·345456	29 292	10·654544	10·010404	29 13	9·989596	2	30
30	50	9·335337	30 288	10·664663	9·345755	30 302	10·654245	10·010418	30 14	9·989582	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

77° — 5ʰ 10ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 50m — 12°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·335337		10·664663	9·345755		10·654245	10·010418		9·989582	10	30
30	2	9·335622	1″ 9	10·664378	9·346054	1″ 10	10·653946	10·010432	1″ 0	9·989568	58	30
31	4	9·335906	2 19	10·664094	9·346353	2 20	10·653647	10·010447	2 1	9·989553	56	29
30	6	9·336191	3 28	10·663809	9·346651	3 30	10·653349	10·010461	3 1	9·989539	54	30
32	8	9·336475	4 38	10·663525	9·346949	4 39	10·653051	10·010475	4 2	9·989525	52	28
30	10	9·336759	5 47	10·663241	9·347248	5 49	10·652752	10·010489	5 2	9·989511	50	30
33	12	9·337043	6 56	10·662957	9·347545	6 59	10·652455	10·010503	6 3	9·989497	48	27
30	14	9·337326	7 66	10·662674	9·347843	7 69	10·652157	10·010517	7 3	9·989483	46	30
34	16	9·337610	8 75	10·662390	9·348141	8 80	10·651859	10·010531	8 4	9·989469	44	26
30	18	9·337893	9 85	10·662107	9·348438	9 89	10·651562	10·010545	9 4	9·989455	42	30
35	20	9·338176	10 94	10·661824	9·348735	10 99	10·651265	10·010559	10 5	9·989441	40	25
30	22	9·338459	11 103	10·661541	9·349032	11 109	10·650968	10·010573	11 5	9·989427	38	30
36	24	9·338742	12 113	10·661258	9·349329	12 118	10·650671	10·010587	12 6	9·989413	36	24
30	26	9·339024	13 122	10·660976	9·349626	13 128	10·650374	10·010601	13 6	9·989399	34	30
37	28	9·339307	14 132	10·660693	9·349922	14 138	10·650078	10·010615	14 7	9·989385	32	23
30	30	9·339589	15 141	10·660411	9·350218	15 148	10·649782	10·010630	15 7	9·989370	30	30
38	32	9·339871	16 150	10·660129	9·350514	16 158	10·649486	10·010644	16 8	9·989356	28	22
30	34	9·340152	17 160	10·659848	9·350810	17 168	10·649190	10·010658	17 8	9·989342	26	30
39	36	9·340434	18 169	10·659566	9·351106	18 178	10·648894	10·010672	18 8	9·989328	24	21
30	38	9·340715	19 179	10·659285	9·351401	19 188	10·648599	10·010686	19 9	9·989314	22	30
40	40	9·340996	20 188	10·659004	9·351697	20 197	10·648303	10·010700	20 9	9·989300	20	20
30	42	9·341277	21 197	10·658723	9·351992	21 207	10·648008	10·010715	21 10	9·989285	18	30
41	44	9·341558	22 207	10·658442	9·352287	22 217	10·647713	10·010729	22 10	9·989271	16	19
30	46	9·341839	23 216	10·658161	9·352582	23 227	10·647418	10·010743	23 11	9·989257	14	30
42	48	9·342119	24 226	10·657881	9·352876	24 237	10·647124	10·010757	24 11	9·989243	12	18
30	50	9·342399	25 235	10·657601	9·353171	25 247	10·646829	10·010772	25 12	9·989228	10	30
43	52	9·342679	26 244	10·657321	9·353465	26 257	10·646535	10·010786	26 12	9·989214	8	17
30	54	9·342959	27 254	10·657041	9·353759	27 266	10·646241	10·010800	27 13	9·989200	6	30
44	56	9·343239	28 263	10·656761	9·354053	28 276	10·645947	10·010814	28 13	9·989186	4	16
30	58	9·343518	29 273	10·656482	9·354347	29 286	10·645653	10·010829	29 14	9·989171	2	30
45	51	9·343797	30 282	10·656203	9·354640	30 296	10·645360	10·010843	30 14	9·989157	9	15
30	2	9·344076	1 9	10·655924	9·354934	1 10	10·645066	10·010857	1 0	9·989143	58	30
46	4	9·344355	2 18	10·655645	9·355227	2 19	10·644773	10·010872	2 1	9·989128	56	14
30	6	9·344634	3 28	10·655366	9·355520	3 29	10·644480	10·010886	3 1	9·989114	54	30
47	8	9·344912	4 37	10·655088	9·355813	4 39	10·644187	10·010900	4 2	9·989100	52	13
30	10	9·345191	5 46	10·654809	9·356105	5 48	10·643895	10·010915	5 2	9·989085	50	30
48	12	9·345469	6 55	10·654531	9·356398	6 58	10·643602	10·010929	6 3	9·989071	48	12
30	14	9·345747	7 64	10·654253	9·356690	7 68	10·643310	10·010943	7 3	9·989057	46	30
49	16	9·346024	8 73	10·653976	9·356982	8 77	10·643018	10·010958	8 4	9·989042	44	11
30	18	9·346302	9 83	10·653698	9·357274	9 87	10·642726	10·010972	9 4	9·989028	42	30
50	20	9·346579	10 92	10·653421	9·357566	10 97	10·642434	10·010986	10 5	9·989014	40	10
30	22	9·346857	11 101	10·653143	9·357857	11 106	10·642143	10·011001	11 5	9·988999	38	30
51	24	9·347134	12 111	10·652866	9·358149	12 116	10·641851	10·011015	12 6	9·988985	36	9
30	26	9·347410	13 120	10·652590	9·358440	13 126	10·641560	10·011030	13 6	9·988970	34	30
52	28	9·347687	14 129	10·652313	9·358731	14 135	10·641269	10·011044	14 7	9·988956	32	8
30	30	9·347963	15 138	10·652037	9·359022	15 145	10·640978	10·011058	15 7	9·988942	30	30
53	32	9·348240	16 147	10·651760	9·359313	16 155	10·640687	10·011073	16 8	9·988927	28	7
30	34	9·348516	17 157	10·651484	9·359603	17 164	10·640397	10·011087	17 8	9·988913	26	30
54	36	9·348792	18 166	10·651208	9·359893	18 174	10·640107	10·011102	18 9	9·988898	24	6
30	38	9·349067	19 175	10·650933	9·360184	19 184	10·639816	10·011116	19 9	9·988884	22	30
55	40	9·349343	20 184	10·650657	9·360474	20 193	10·639526	10·011131	20 10	9·988869	20	5
30	42	9·349618	21 193	10·650382	9·360763	21 203	10·639237	10·011145	21 10	9·988855	18	30
56	44	9·349893	22 203	10·650107	9·361053	22 213	10·638947	10·011160	22 11	9·988840	16	4
30	46	9·350168	23 212	10·649832	9·361343	23 222	10·638657	10·011174	23 11	9·988826	14	30
57	48	9·350443	24 221	10·649557	9·361632	24 232	10·638368	10·011189	24 12	9·988811	12	3
30	50	9·350718	25 230	10·649282	9·361921	25 242	10·638079	10·011203	25 12	9·988797	10	30
58	52	9·350992	26 239	10·649008	9·362210	26 251	10·637790	10·011218	26 12	9·988782	8	2
30	54	9·351266	27 249	10·648734	9·362499	27 261	10·637501	10·011232	27 13	9·988768	6	30
59	56	9·351540	28 258	10·648460	9·362787	28 271	10·637213	10·011247	28 13	9·988753	4	1
30	58	9·351814	29 267	10·648186	9·363076	29 280	10·636924	10·011261	29 14	9·988739	2	30
60	52	9·352088	30 276	10·647912	9·363364	30 290	10·636636	10·011276	30 14	9·988724	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

77° — 5h 8m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 52m — 13°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·352088		10·647912	9·363364		10·636636	10·011276		9·988724	8	60
30	2	9·352362	1″ 9	10·647638	9·363652	1″ 10	10·636348	10·011291	1″ 0	9·988709	58	30
1	4	9·352635	2 18	10·647365	9·363940	2 19	10·636060	10·011305	2 1	9·988695	56	59
30	6	9·352908	3 27	10·647092	9·364228	3 29	10·635772	10·011320	3 1	9·988680	54	30
2	8	9·353181	4 36	10·646819	9·364515	4 38	10·635485	10·011334	4 2	9·988666	52	58
30	10	9·353454	5 45	10·646546	9·364803	5 48	10·635197	10·011349	5 2	9·988651	50	30
3	12	9·353726	6 54	10·646274	9·365090	6 57	10·634910	10·011364	6 3	9·988636	48	57
30	14	9·353999	7 63	10·646001	9·365377	7 67	10·634623	10·011378	7 3	9·988622	46	30
4	16	9·354271	8 72	10·645729	9·365664	8 76	10·634336	10·011393	8 4	9·988607	44	56
30	18	9·354543	9 81	10·645457	9·365951	9 86	10·634049	10·011408	9 4	9·988592	42	30
5	20	9·354815	10 90	10·645185	9·366237	10 95	10·633763	10·011422	10 5	9·988578	40	55
30	22	9·355087	11 99	10·644913	9·366524	11 105	10·633476	10·011437	11 5	9·988563	38	30
6	24	9·355358	12 108	10·644642	9·366810	12 114	10·633190	10·011452	12 6	9·988548	36	54
30	26	9·355630	13 117	10·644370	9·367096	13 124	10·632904	10·011466	13 6	9·988534	34	30
7	28	9·355901	14 126	10·644099	9·367382	14 133	10·632618	10·011481	14 7	9·988519	32	53
30	30	9·356172	15 135	10·643828	9·367668	15 143	10·632332	10·011496	15 7	9·988504	30	30
8	32	9·356443	16 144	10·643557	9·367953	16 152	10·632047	10·011511	16 8	9·988489	28	52
30	34	9·356713	17 153	10·643287	9·368239	17 162	10·631761	10·011525	17 8	9·988475	26	30
9	36	9·356984	18 162	10·643016	9·368524	18 171	10·631476	10·011540	18 9	9·988460	24	51
30	38	9·357254	19 171	10·642746	9·368809	19 181	10·631191	10·011555	19 9	9·988445	22	30
10	40	9·357524	20 181	10·642476	9·369094	20 190	10·630906	10·011570	20 10	9·988430	20	50
30	42	9·357794	21 190	10·642206	9·369378	21 200	10·630622	10·011584	21 10	9·988416	18	30
11	44	9·358064	22 199	10·641936	9·369663	22 209	10·630337	10·011599	22 11	9·988401	16	49
30	46	9·358333	23 208	10·641667	9·369947	23 219	10·630053	10·011614	23 11	9·988386	14	30
12	48	9·358603	24 217	10·641397	9·370232	24 228	10·629768	10·011629	24 12	9·988371	12	48
30	50	9·358872	25 226	10·641128	9·370516	25 238	10·629484	10·011644	25 12	9·988356	10	30
13	52	9·359141	26 235	10·640859	9·370799	26 248	10·629201	10·011658	26 13	9·988342	8	47
30	54	9·359410	27 244	10·640590	9·371083	27 257	10·628917	10·011673	27 13	9·988327	6	30
14	56	9·359678	28 253	10·640322	9·371367	28 267	10·628633	10·011688	28 14	9·988312	4	46
30	58	9·359947	29 262	10·640053	9·371650	29 276	10·628350	10·011703	29 14	9·988297	2	30
15	53	9·360215	30 271	10·639785	9·371933	30 286	10·628067	10·011718	30 15	9·988282	7	45
30	2	9·360484	1 9	10·639516	9·372216	1 10	10·627784	10·011733	1 0	9·988267	58	30
16	4	9·360752	2 18	10·639248	9·372499	2 19	10·627501	10·011748	2 1	9·988252	56	44
30	6	9·361019	3 26	10·638981	9·372782	3 28	10·627218	10·011763	3 1	9·988237	54	30
17	8	9·361287	4 35	10·638713	9·373064	4 37	10·626936	10·011777	4 2	9·988223	52	43
30	10	9·361554	5 44	10·638446	9·373347	5 47	10·626653	10·011792	5 2	9·988208	50	30
18	12	9·361822	6 53	10·638178	9·373629	6 56	10·626371	10·011807	6 3	9·988193	48	42
30	14	9·362089	7 62	10·637911	9·373911	7 65	10·626089	10·011822	7 3	9·988178	46	30
19	16	9·362356	8 70	10·637644	9·374193	8 75	10·625807	10·011837	8 4	9·988163	44	41
30	18	9·362623	9 79	10·637377	9·374475	9 84	10·625525	10·011852	9 4	9·988148	42	30
20	20	9·362889	10 88	10·637111	9·374756	10 93	10·625244	10·011867	10 5	9·988133	40	40
30	22	9·363156	11 97	10·636844	9·375038	11 103	10·624962	10·011882	11 5	9·988118	38	30
21	24	9·363422	12 106	10·636578	9·375319	12 112	10·624681	10·011897	12 6	9·988103	36	39
30	26	9·363688	13 115	10·636312	9·375600	13 122	10·624400	10·011912	13 6	9·988088	34	30
22	28	9·363954	14 124	10·636046	9·375881	14 131	10·624119	10·011927	14 7	9·988073	32	38
30	30	9·364220	15 133	10·635780	9·376162	15 140	10·623838	10·011942	15 7	9·988058	30	30
23	32	9·364485	16 142	10·635515	9·376442	16 150	10·623558	10·011957	16 8	9·988043	28	37
30	34	9·364751	17 151	10·635249	9·376723	17 158	10·623277	10·011972	17 8	9·988028	26	30
24	36	9·365016	18 159	10·634984	9·377003	18 168	10·622997	10·011987	18 9	9·988013	24	36
30	38	9·365281	19 168	10·634719	9·377283	19 178	10·622717	10·012002	19 9	9·987998	22	30
25	40	9·365546	20 177	10·634454	9·377563	20 187	10·622437	10·012017	20 10	9·987983	20	35
30	42	9·365810	21 186	10·634190	9·377843	21 196	10·622157	10·012032	21 10	9·987968	18	30
26	44	9·366075	22 195	10·633925	9·378122	22 206	10·621878	10·012047	22 11	9·987953	16	34
30	46	9·366339	23 203	10·633661	9·378402	23 215	10·621598	10·012063	23 11	9·987937	14	30
27	48	9·366604	24 212	10·633396	9·378681	24 224	10·621319	10·012078	24 12	9·987922	12	33
30	50	9·366868	25 221	10·633132	9·378960	25 234	10·621040	10·012093	25 12	9·987907	10	30
28	52	9·367131	26 230	10·632869	9·379239	26 243	10·620761	10·012108	26 13	9·987892	8	32
30	54	9·367395	27 239	10·632605	9·379518	27 252	10·620482	10·012123	27 13	9·987877	6	30
29	56	9·367659	28 248	10·632341	9·379797	28 262	10·620203	10·012138	28 14	9·987862	4	31
30	58	9·367922	29 257	10·632078	9·380075	29 271	10·619925	10·012153	29 14	9·987847	2	30
30	54	9·368185	30 265	10·631815	9·380354	30 280	10·619646	10·012168	30 15	9·987832	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

76° — 5h 6m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 54m — 13°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·368185		10·631815	9·380354		10·619646	10·012168		9·987832	0	30
30	2	9·368448	1″ 9	10·631552	9·380632	1″ 9	10·619368	10·012184	1″ 1	9·987816	58	30
31	4	9·368711	2 17	10·631289	9·380910	2 18	10·619090	10·012199	2 1	9·987801	56	29
30	6	9·368974	3 26	10·631026	9·381188	3 28	10·618812	10·012214	3 2	9·987786	54	30
32	8	9·369236	4 35	10·630764	9·381466	4 37	10·618534	10·012229	4 2	9·987771	52	28
30	10	9·369499	5 43	10·630501	9·381743	5 46	10·618257	10·012244	5 3	9·987756	50	30
33	12	9·369761	6 52	10·630239	9·382020	6 55	10·617980	10·012260	6 3	9·987740	48	27
30	14	9·370023	7 61	10·629977	9·382298	7 64	10·617702	10·012275	7 4	9·987725	46	30
34	16	9·370285	8 70	10·629715	9·382575	8 74	10·617425	10·012290	8 4	9·987710	44	26
30	18	9·370546	9 78	10·629454	9·382852	9 83	10·617148	10·012305	9 5	9·987695	42	30
35	20	9·370808	10 87	10·629192	9·383129	10 92	10·616871	10·012321	10 5	9·987679	40	25
30	22	9·371069	11 95	10·628931	9·383405	11 101	10·616595	10·012336	11 6	9·987664	38	30
36	24	9·371330	12 104	10·628670	9·383682	12 110	10·616318	10·012351	12 6	9·987649	36	24
30	26	9·371591	13 113	10·628409	9·383958	13 120	10·616042	10·012366	13 7	9·987634	34	30
37	28	9·371852	14 122	10·628148	9·384234	14 129	10·615766	10·012382	14 7	9·987618	32	23
30	30	9·372113	15 130	10·627887	9·384510	15 138	10·615490	10·012397	15 8	9·987603	30	30
38	32	9·372373	16 139	10·627627	9·384786	16 147	10·615214	10·012412	16 8	9·987588	28	22
30	34	9·372634	17 148	10·627366	9·385062	17 156	10·614938	10·012428	17 9	9·987572	26	30
39	36	9·372894	18 156	10·627106	9·385337	18 166	10·614663	10·012443	18 9	9·987557	24	21
30	38	9·373154	19 165	10·626846	9·385612	19 175	10·614388	10·012458	19 10	9·987542	22	30
40	40	9·373414	20 174	10·626586	9·385888	20 184	10·614112	10·012474	20 10	9·987526	20	20
30	42	9·373674	21 182	10·626326	9·386163	21 193	10·613837	10·012489	21 11	9·987511	18	30
41	44	9·373933	22 191	10·626067	9·386438	22 202	10·613562	10·012504	22 11	9·987496	16	19
30	46	9·374192	23 200	10·625808	9·386712	23 212	10·613288	10·012520	23 12	9·987480	14	30
42	48	9·374452	24 208	10·625548	9·386987	24 221	10·613013	10·012535	24 12	9·987465	12	18
30	50	9·374711	25 217	10·625289	9·387261	25 230	10·612739	10·012551	25 13	9·987449	10	30
43	52	9·374970	26 226	10·625030	9·387536	26 239	10·612464	10·012566	26 13	9·987434	8	17
30	54	9·375228	27 235	10·624772	9·387810	27 248	10·612190	10·012581	27 14	9·987419	6	30
44	56	9·375487	28 243	10·624513	9·388084	28 258	10·611916	10·012597	28 14	9·987403	4	16
30	58	9·375745	29 252	10·624855	9·388358	29 267	10·611642	10·012612	29 15	9·987388	2	30
45	55	9·376003	30 261	10·623997	9·388631	30 276	10·611369	10·012628	30 15	9·987372	5	15
30	2	9·376261	1 8	10·623739	9·388905	1 9	10·611095	10·012643	1 1	9·987357	58	30
46	4	9·376519	2 17	10·623481	9·389178	2 18	10·610822	10·012659	2 1	9·987341	56	14
30	6	9·376777	3 25	10·623223	9·389451	3 27	10·610549	10·012674	3 2	9·987326	54	30
47	8	9·377035	4 34	10·622965	9·389724	4 36	10·610276	10·012690	4 2	9·987310	52	13
30	10	9·377292	5 42	10·622708	9·389997	5 45	10·610003	10·012705	5 3	9·987295	50	30
48	12	9·377549	6 51	10·622451	9·390270	6 54	10·609730	10·012721	6 3	9·987279	48	12
30	14	9·377806	7 59	10·622194	9·390543	7 63	10·609457	10·012736	7 4	9·987264	46	30
49	16	9·378063	8 68	10·621937	9·390815	8 72	10·609185	10·012752	8 4	9·987248	44	11
30	18	9·378320	9 76	10·621680	9·391087	9 81	10·608913	10·012767	9 5	9·987233	42	30
50	20	9·378577	10 85	10·621423	9·391360	10 90	10·608640	10·012783	10 5	9·987217	40	10
30	22	9·378833	11 94	10·621167	9·391632	11 99	10·608368	10·012798	11 6	9·987202	38	30
51	24	9·379089	12 102	10·620911	9·391903	12 108	10·608097	10·012814	12 6	9·987186	36	9
30	26	9·379346	13 111	10·620654	9·392175	13 118	10·607825	10·012830	13 7	9·987170	34	30
52	28	9·379601	14 119	10·620399	9·392447	14 127	10·607553	10·012845	14 7	9·987155	32	8
30	30	9·379857	15 128	10·620143	9·392718	15 136	10·607282	10·012861	15 8	9·987139	30	30
53	32	9·380113	16 136	10·619887	9·392989	16 145	10·607011	10·012876	16 8	9·987124	28	7
30	34	9·380368	17 145	10·619632	9·393260	17 154	10·606740	10·012892	17 9	9·987108	26	30
54	36	9·380624	18 153	10·619376	9·393531	18 163	10·606469	10·012908	18 9	9·987092	24	6
30	38	9·380879	19 162	10·619121	9·393802	19 172	10·606198	10·012923	19 10	9·987077	22	30
55	40	9·381134	20 170	10·618866	9·394073	20 181	10·605927	10·012939	20 10	9·987061	20	5
30	42	9·381389	21 179	10·618611	9·394343	21 190	10·605657	10·012955	21 11	9·987045	18	30
56	44	9·381643	22 187	10·618357	9·394614	22 199	10·605386	10·012970	22 11	9·987030	16	4
30	46	9·381898	23 196	10·618102	9·394884	23 208	10·605116	10·012986	23 12	9·987014	14	30
57	48	9·382152	24 204	10·617848	9·395154	24 217	10·604846	10·013002	24 12	9·986998	12	3
30	50	9·382406	25 213	10·617594	9·395424	25 226	10·604576	10·013017	25 13	9·986983	10	30
58	52	9·382661	26 222	10·617339	9·395694	26 235	10·604306	10·013033	26 14	9·986967	8	2
30	54	9·382914	27 230	10·617086	9·395963	27 244	10·604037	10·013049	27 14	9·986951	6	30
59	56	9·383168	28 239	10·616832	9·396233	28 253	10·603767	10·013064	28 15	9·986936	4	1
30	58	9·383422	29 247	10·616578	9·396502	29 262	10·603498	10·013080	29 15	9·986920	2	30
60	56	9·383675	30 256	10·616325	9·396771	30 271	10·603229	10·013096	30 16	9·986904	0	0
′ ″	m. s.	Cosine	Parts	Secant.	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

76° — 5h 4m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0h 56m — 14°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·383675		10·616325	9·396771		10·603229	10·013096		9·986904	4	60
30	2	9·383928	1″ 8	10·616072	9·397040	1″ 9	10·602960	10·013112	1″ 1	9·986888	58	30
1	4	9·384182	2 17	10·615818	9·397309	2 18	10·602691	10·013127	2 1	9·986873	56	59
30	6	9·384435	3 25	10·615565	9·397578	3 27	10·602422	10·013143	3 2	9·986857	54	30
2	8	9·384687	4 33	10·615313	9·397846	4 36	10·602154	10·013159	4 2	9·986841	52	58
30	10	9·384940	5 42	10·615060	9·398115	5 44	10·601885	10·013175	5 3	9·986825	50	30
3	12	9·385192	6 50	10·614808	9·398383	6 53	10·601617	10·013191	6 3	9·986809	48	57
30	14	9·385445	7 59	10·614555	9·398651	7 62	10·601349	10·013206	7 4	9·986794	46	30
4	16	9·385697	8 67	10·614303	9·398919	8 71	10·601081	10·013222	8 4	9·986778	44	56
30	18	9·385949	9 75	10·614051	9·399187	9 80	10·600813	10·013238	9 5	9·986762	42	30
5	20	9·386201	10 84	10·613799	9·399455	10 89	10·600545	10·013254	10 5	9·986746	40	55
30	22	9·386452	11 92	10·613548	9·399722	11 98	10·600278	10·013270	11 6	9·986730	38	30
6	24	9·386704	12 100	10·613296	9·399990	12 107	10·600010	10·013286	12 6	9·986714	36	54
30	26	9·386955	13 109	10·613045	9·400257	13 116	10·599743	10·013301	13 7	9·986699	34	30
7	28	9·387207	14 118	10·612793	9·400524	14 125	10·599476	10·013317	14 7	9·986683	32	53
30	30	9·387458	15 126	10·612542	9·400791	15 133	10·599209	10·013333	15 8	9·986667	30	30
8	32	9·387709	16 134	10·612291	9·401058	16 142	10·598942	10·013349	16 8	9·986651	28	52
30	34	9·387959	17 142	10·612041	9·401325	17 151	10·598675	10·013365	17 9	9·986635	26	30
9	36	9·388210	18 150	10·611790	9·401591	18 160	10·598409	10·013381	18 10	9·986619	24	51
30	38	9·388461	19 159	10·611539	9·401857	19 169	10·598143	10·013397	19 10	9·986603	22	30
10	40	9·388711	20 167	10·611289	9·402124	20 178	10·597876	10·013413	20 11	9·986587	20	50
30	42	9·388961	21 176	10·611039	9·402390	21 187	10·597610	10·013429	21 11	9·986571	18	30
11	44	9·389211	22 184	10·610789	9·402656	22 196	10·597344	10·013445	22 12	9·986555	16	49
30	46	9·389461	23 192	10·610539	9·402922	23 205	10·597078	10·013461	23 12	9·986539	14	30
12	48	9·389711	24 201	10·610289	9·403187	24 214	10·596813	10·013477	24 13	9·986523	12	48
30	50	9·389960	25 209	10·610040	9·403453	25 222	10·596547	10·013493	25 13	9·986507	10	30
13	52	9·390210	26 218	10·609790	9·403718	26 231	10·596282	10·013509	26 14	9·986491	8	47
30	54	9·390459	27 227	10·609541	9·403983	27 240	10·596017	10·013525	27 14	9·986475	6	30
14	56	9·390708	28 236	10·609292	9·404249	28 249	10·595751	10·013541	28 15	9·986459	4	46
30	58	9·390957	29 244	10·609043	9·404514	29 258	10·595486	10·013557	29 15	9·986443	2	30
15	57	9·391206	30 251	10·608794	9·404778	30 267	10·595222	10·013573	30 16	9·986427	3	45
30	2	9·391454	1 8	10·608546	9·405043	1 9	10·594957	10·013589	1 1	9·986411	58	30
16	4	9·391703	2 16	10·608297	9·405308	2 17	10·594692	10·013605	2 1	9·986395	56	44
30	6	9·391951	3 25	10·608049	9·405572	3 26	10·594428	10·013621	3 2	9·986379	54	30
17	8	9·392199	4 33	10·607801	9·405836	4 35	10·594164	10·013637	4 2	9·986363	52	43
30	10	9·392447	5 41	10·607553	9·406100	5 44	10·593900	10·013653	5 3	9·986347	50	30
18	12	9·392695	6 49	10·607305	9·406364	6 52	10·593636	10·013669	6 3	9·986331	48	42
30	14	9·392943	7 57	10·607057	9·406628	7 61	10·593372	10·013685	7 4	9·986315	46	30
19	16	9·393191	8 66	10·606809	9·406892	8 70	10·593108	10·013701	8 4	9·986299	44	41
30	18	9·393438	9 74	10·606562	9·407155	9 79	10·592845	10·013718	9 5	9·986282	42	30
20	20	9·393685	10 82	10·606315	9·407419	10 87	10·592581	10·013734	10 5	9·986266	40	40
30	22	9·393932	11 90	10·606068	9·407682	11 96	10·592318	10·013750	11 6	9·986250	38	30
21	24	9·394179	12 98	10·605821	9·407945	12 105	10·592055	10·013766	12 6	9·986234	36	39
30	26	9·394426	13 106	10·605574	9·408208	13 114	10·591792	10·013782	13 7	9·986218	34	30
22	28	9·394673	14 114	10·605327	9·408471	14 122	10·591529	10·013798	14 8	9·986202	32	38
30	30	9·394919	15 123	10·605081	9·408734	15 131	10·591266	10·013814	15 8	9·986186	30	30
23	32	9·395166	16 132	10·604834	9·408996	16 140	10·591004	10·013831	16 9	9·986169	28	37
30	34	9·395412	17 140	10·604588	9·409259	17 149	10·590741	10·013847	17 9	9·986153	26	30
24	36	9·395658	18 148	10·604342	9·409521	18 157	10·590479	10·013863	18 10	9·986137	24	36
30	38	9·395904	19 156	10·604096	9·409783	19 166	10·590217	10·013879	19 10	9·986121	22	30
25	40	9·396150	20 164	10·603850	9·410045	20 175	10·589955	10·013896	20 11	9·986104	20	35
30	42	9·396395	21 172	10·603605	9·410307	21 184	10·589693	10·013912	21 11	9·986088	18	30
26	44	9·396641	22 180	10·603359	9·410569	22 192	10·589431	10·013928	22 12	9·986072	16	34
30	46	9·396886	23 189	10·603114	9·410831	23 201	10·589169	10·013944	23 12	9·986056	14	30
27	48	9·397132	24 197	10·602868	9·411092	24 210	10·588908	10·013961	24 13	9·986039	12	33
30	50	9·397377	25 205	10·602623	9·411353	25 219	10·588647	10·013977	25 13	9·986023	10	30
28	52	9·397621	26 213	10·602379	9·411615	26 227	10·588385	10·013993	26 14	9·986007	8	32
30	54	9·397866	27 221	10·602134	9·411876	27 236	10·588124	10·014009	27 15	9·985991	6	30
29	56	9·398111	28 229	10·601889	9·412137	28 245	10·587863	10·014026	28 15	9·985974	4	31
30	58	9·398355	29 237	10·601645	9·412397	29 254	10·587603	10·014042	29 16	9·985958	2	30
30	58	9·398600	30 246	10·601400	9·412658	30 262	10·587342	10·014058	30 16	9·985942	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

75° — 5h 2m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

0ʰ 58ᵐ 14°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·398600		10·601400	9·412658		10·587342	10·014058		9·985942	2	30
30	2	9·398844	1″ 8	10·601156	9·412919	1″ 9	10·587081	10·014075	1″ 1	9·985925	58	30
31	4	9·399088	2 16	10·600912	9·413179	2 17	10·586821	10·014091	2 1	9·985909	56	29
30	6	9·399332	3 24	10·600668	9·413439	3 26	10·586561	10·014107	3 2	9·985893	54	30
32	8	9·399575	4 32	10·600425	9·413699	4 34	10·586301	10·014124	4 2	9·985876	52	28
30	10	9·399819	5 40	10·600181	9·413959	5 43	10·586041	10·014140	5 3	9·985860	50	30
33	12	9·400062	6 48	10·599938	9·414219	6 52	10·585781	10·014157	6 3	9·985843	48	27
30	14	9·400306	7 56	10·599694	9·414479	7 60	10·585521	10·014173	7 4	9·985827	46	30
34	16	9·400549	8 65	10·599451	9·414738	8 69	10·585262	10·014189	8 4	9·985811	44	26
30	18	9·400792	9 73	10·599208	9·414998	9 78	10·585002	10·014206	9 5	9·985794	42	30
35	20	9·401035	10 81	10·598965	9·415257	10 86	10·584743	10·014222	10 5	9·985778	40	25
30	22	9·401277	11 89	10·598723	9·415516	11 95	10·584484	10·014239	11 6	9·985761	38	30
36	24	9·401520	12 96	10·598480	9·415775	12 103	10·584225	10·014255	12 7	9·985745	36	24
30	26	9·401762	13 104	10·598238	9·416034	13 112	10·583966	10·014272	13 7	9·985728	34	30
37	28	9·402005	14 112	10·597995	9·416293	14 121	10·583707	10·014288	14 8	9·985712	32	23
30	30	9·402247	15 120	10·597753	9·416551	15 129	10·583449	10·014305	15 8	9·985695	30	30
38	32	9·402489	16 129	10·597511	9·416810	16 138	10·583190	10·014321	16 9	9·985679	28	22
30	34	9·402731	17 137	10·597269	9·417068	17 147	10·582932	10·014338	17 9	9·985662	26	30
39	36	9·402972	18 145	10·597028	9·417326	18 155	10·582674	10·014354	18 10	9·985646	24	21
30	38	9·403214	19 153	10·596786	9·417585	19 164	10·582415	10·014371	19 10	9·985629	22	30
40	40	9·403455	20 161	10·596545	9·417842	20 172	10·582158	10·014387	20 11	9·985613	20	20
30	42	9·403697	21 169	10·596303	9·418100	21 181	10·581900	10·014404	21 12	9·985596	18	30
41	44	9·403938	22 178	10·596062	9·418358	22 190	10·581642	10·014420	22 12	9·985580	16	19
30	46	9·404179	23 186	10·595821	9·418616	23 198	10·581384	10·014437	23 13	9·985563	14	30
42	48	9·404420	24 194	10·595580	9·418873	24 207	10·581127	10·014453	24 13	9·985547	12	18
30	50	9·404660	25 202	10·595340	9·419130	25 215	10·580870	10·014470	25 14	9·985530	10	30
43	52	9·404901	26 210	10·595099	9·419387	26 224	10·580613	10·014486	26 14	9·985514	8	17
30	54	9·405141	27 218	10·594859	9·419644	27 233	10·580356	10·014503	27 15	9·985497	6	30
44	56	9·405382	28 226	10·594618	9·419901	28 241	10·580099	10·014520	28 15	9·985480	4	16
30	58	9·405622	29 234	10·594378	9·420158	29 250	10·579842	10·014536	29 16	9·985464	2	30
45	59	9·405862	30 242	10·594138	9·420415	30 259	10·579585	10·014553	30 16	9·985447	2	15
30	2	9·406102	1 8	10·593898	9·420671	1 8	10·579329	10·014570	1 1	9·985430	58	30
46	4	9·406341	2 16	10·593659	9·420927	2 17	10·579073	10·014586	2 1	9·985414	56	14
30	6	9·406581	3 24	10·593419	9·421184	3 25	10·578816	10·014603	3 2	9·985397	54	30
47	8	9·406820	4 32	10·593180	9·421440	4 34	10·578560	10·014619	4 2	9·985381	52	13
30	10	9·407060	5 40	10·592940	9·421696	5 42	10·578304	10·014636	5 3	9·985364	50	30
48	12	9·407299	6 48	10·592701	9·421952	6 51	10·578048	10·014653	6 3	9·985347	48	12
30	14	9·407538	7 55	10·592462	9·422207	7 59	10·577793	10·014670	7 4	9·985330	46	30
49	16	9·407777	8 63	10·592223	9·422463	8 68	10·577537	10·014686	8 4	9·985314	44	11
30	18	9·408015	9 71	10·591985	9·422718	9 76	10·577282	10·014703	9 5	9·985297	42	30
50	20	9·408254	10 79	10·591746	9·422974	10 85	10·577026	10·014720	10 6	9·985280	40	10
30	22	9·408492	11 87	10·591508	9·423229	11 93	10·576771	10·014736	11 6	9·985264	28	30
51	24	9·408731	12 95	10·591269	9·423484	12 102	10·576516	10·014753	12 7	9·985247	36	9
30	26	9·408969	13 103	10·591031	9·423739	13 110	10·576261	10·014770	13 7	9·985230	34	30
52	28	9·409207	14 111	10·590793	9·423993	14 119	10·576007	10·014787	14 8	9·985213	32	8
30	30	9·409445	15 118	10·590555	9·424248	15 127	10·575752	10·014803	15 8	9·985197	30	30
53	32	9·409682	16 126	10·590318	9·424503	16 136	10·575497	10·014820	16 9	9·985180	28	7
30	34	9·409920	17 134	10·590080	9·424757	17 144	10·575243	10·014837	17 10	9·985163	26	30
54	36	9·410157	18 142	10·589843	9·425011	18 153	10·574989	10·014854	18 10	9·985146	24	6
30	38	9·410395	19 150	10·589605	9·425265	19 161	10·574735	10·014871	19 11	9·985129	22	30
55	40	9·410632	20 158	10·589368	9·425519	20 170	10·574481	10·014887	20 11	9·985113	20	5
30	42	9·410869	21 166	10·589131	9·425773	21 178	10·574227	10·014904	21 12	9·985096	18	30
56	44	9·411106	22 174	10·588894	9·426027	22 187	10·573973	10·014921	22 12	9·985079	16	4
30	46	9·411343	23 182	10·588657	9·426281	23 195	10·573719	10·014938	23 13	9·985062	14	30
57	48	9·411579	24 190	10·588421	9·426534	24 204	10·573466	10·014955	24 13	9·985045	12	3
30	50	9·411816	25 198	10·588184	9·426787	25 212	10·573212	10·014972	25 14	9·985028	10	30
58	52	9·412052	26 206	10·587948	9·427041	26 220	10·572959	10·014989	26 15	9·985011	8	2
30	54	9·412288	27 214	10·587712	9·427294	27 229	10·572706	10·015005	27 15	9·984995	6	30
59	56	9·412524	28 222	10·587476	9·427547	28 237	10·572453	10·015022	28 16	9·984978	4	1
30	58	9·412760	29 230	10·587240	9·427800	29 246	10·572200	10·015039	29 16	9·984961	2	30
60	60	9·412996	30 238	10·587004	9·428052	30 254	10·571948	10·015056	30 17	9·984944	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

75° 5ʰ 0ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1h 0m — 15°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·412996		10·587004	9·428052		10·571948	10·015056		9·984944	60	60
30	2	9·413232	1″ 8	10·586768	9·428305	1″ 8	10·571695	10·015073	1″ 1	9·984927	58	30
1	4	9·413467	2 16	10·586533	9·428558	2 17	10·571442	10·015090	2 1	9·984910	56	59
30	6	9·413703	3 23	10·586297	9·428810	3 25	10·571190	10·015107	3 2	9·984893	54	30
2	8	9·413938	4 31	10·586062	9·429062	4 33	10·570938	10·015124	4 2	9·984876	52	58
30	10	9·414173	5 39	10·585827	9·429314	5 42	10·570686	10·015141	5 3	9·984859	50	30
3	12	9·414408	6 47	10·585592	9·429566	6 50	10·570434	10·015158	6 3	9·984842	48	57
30	14	9·414643	7 55	10·585357	9·429818	7 59	10·570182	10·015175	7 4	9·984825	46	30
4	16	9·414878	8 62	10·585122	9·430070	8 67	10·569930	10·015192	8 5	9·984808	44	56
30	18	9·415112	9 70	10·584888	9·430321	9 75	10·569679	10·015209	9 5	9·984791	42	30
5	20	9·415347	10 78	10·584653	9·430573	10 84	10·569427	10·015226	10 6	9·984774	40	55
30	22	9·415581	11 86	10·584419	9·430824	11 92	10·569176	10·015243	11 6	9·984757	38	30
6	24	9·415815	12 94	10·584185	9·431075	12 100	10·568925	10·015260	12 7	9·984740	36	54
30	26	9·416049	13 101	10·583951	9·431326	13 109	10·568674	10·015277	13 7	9·984723	34	30
7	28	9·416283	14 109	10·583717	9·431577	14 117	10·568423	10·015294	14 8	9·984706	32	53
30	30	9·416517	15 117	10·583483	9·431828	15 125	10·568172	10·015311	15 9	9·984689	30	30
8	32	9·416751	16 125	10·583249	9·432079	16 134	10·567921	10·015328	16 9	9·984672	28	52
30	34	9·416984	17 133	10·583016	9·432329	17 142	10·567671	10·015345	17 10	9·984655	26	30
9	36	9·417217	18 140	10·582783	9·432580	18 150	10·567420	10·015362	18 10	9·984638	24	51
30	38	9·417451	19 148	10·582549	9·432830	19 159	10·567170	10·015380	19 11	9·984620	22	30
10	40	9·417684	20 156	10·582316	9·433080	20 167	10·566920	10·015397	20 11	9·984603	20	50
30	42	9·417917	21 164	10·582083	9·433331	21 176	10·566669	10·015414	21 12	9·984586	18	30
11	44	9·418150	22 171	10·581850	9·433580	22 184	10·566420	10·015431	22 13	9·984569	16	49
30	46	9·418382	23 179	10·581618	9·433830	23 192	10·566170	10·015448	23 13	9·984552	14	30
12	48	9·418615	24 187	10·581385	9·434080	24 201	10·565920	10·015465	24 14	9·984535	12	48
30	50	9·418847	25 195	10·581153	9·434330	25 209	10·565670	10·015482	25 14	9·984518	10	30
13	52	9·419079	26 203	10·580921	9·434579	26 217	10·565421	10·015500	26 15	9·984500	8	47
30	54	9·419312	27 210	10·580688	9·434828	27 226	10·565172	10·015517	27 15	9·984483	6	30
14	56	9·419544	28 218	10·580456	9·435078	28 234	10·564922	10·015534	28 16	9·984466	4	46
30	58	9·419776	29 226	10·580224	9·435327	29 242	10·564673	10·015551	29 17	9·984449	2	30
15	1	9·420007	30 234	10·579993	9·435576	30 251	10·564424	10·015568	30 17	9·984432	59	45
30	2	9·420239	1 8	10·579761	9·435825	1 8	10·564175	10·015586	1 1	9·984414	58	30
16	4	9·420470	2 15	10·579530	9·436073	2 16	10·563927	10·015603	2 1	9·984397	56	44
30	6	9·420702	3 23	10·579298	9·436322	3 25	10·563678	10·015620	3 2	9·984380	54	30
17	8	9·420933	4 31	10·579067	9·436570	4 33	10·563430	10·015637	4 2	9·984363	52	43
30	10	9·421164	5 38	10·578836	9·436819	5 41	10·563181	10·015655	5 3	9·984345	50	30
18	12	9·421395	6 46	10·578605	9·437067	6 49	10·562933	10·015672	6 3	9·984328	48	42
30	14	9·421626	7 54	10·578374	9·437315	7 58	10·562685	10·015689	7 4	9·984311	46	30
19	16	9·421857	8 61	10·578143	9·437563	8 66	10·562437	10·015706	8 5	9·984294	44	41
30	18	9·422087	9 69	10·577913	9·437811	9 74	10·562189	10·015724	9 5	9·984276	42	30
20	20	9·422318	10 77	10·577682	9·438059	10 82	10·561941	10·015741	10 6	9·984259	40	40
30	22	9·422548	11 85	10·577452	9·438306	11 91	10·561694	10·015758	11 6	9·984242	38	30
21	24	9·422778	12 92	10·577222	9·438554	12 99	10·561446	10·015776	12 7	9·984224	36	39
30	26	9·423008	13 100	10·576992	9·438801	13 107	10·561199	10·015793	13 8	9·984207	34	30
22	28	9·423238	14 108	10·576762	9·439048	14 115	10·560952	10·015810	14 8	9·984190	32	38
30	30	9·423468	15 115	10·576532	9·439296	15 123	10·560704	10·015828	15 9	9·984172	30	30
23	32	9·423697	16 123	10·576303	9·439543	16 132	10·560457	10·015845	16 9	9·984155	28	37
30	34	9·423927	17 131	10·576073	9·439790	17 140	10·560210	10·015863	17 10	9·984137	26	30
24	36	9·424156	18 138	10·575844	9·440036	18 148	10·559964	10·015880	18 10	9·984120	24	36
30	38	9·424386	19 146	10·575614	9·440283	19 156	10·559717	10·015897	19 11	9·984103	22	30
25	40	9·424615	20 153	10·575385	9·440529	20 165	10·559471	10·015915	20 12	9·984085	20	35
30	42	9·424844	21 161	10·575156	9·440776	21 173	10·559224	10·015932	21 12	9·984068	18	30
26	44	9·425073	22 169	10·574927	9·441022	22 181	10·558978	10·015950	22 13	9·984050	16	34
30	46	9·425301	23 176	10·574699	9·441268	23 189	10·558732	10·015967	23 13	9·984033	14	30
27	48	9·425530	24 184	10·574470	9·441514	24 198	10·558486	10·015985	24 14	9·984015	12	33
30	50	9·425758	25 192	10·574242	9·441760	25 206	10·558240	10·016002	25 14	9·983998	10	30
28	52	9·425987	26 199	10·574013	9·442006	26 214	10·557994	10·016019	26 15	9·983981	8	32
30	54	9·426215	27 207	10·573785	9·442252	27 222	10·557748	10·016037	27 16	9·983963	6	30
29	56	9·426443	28 215	10·573557	9·442497	28 230	10·557503	10·016054	28 16	9·983946	4	31
30	58	9·426671	29 222	10·573329	9·442743	29 239	10·557257	10·016072	29 17	9·983928	2	30
30	2	9·426899	30 230	10·573101	9·442988	30 247	10·557012	10·016089	30 17	9·983911	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

74° — 4h 58m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1h 2m — 15°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·426899		10·573101	9·442988		10·557012	10·016089		9·983911	58	30
30	2	9·427127	1″ 8	10·572873	9·443234	1″ 8	10·556766	10·016107	1″ 1	9·983893	58	30
31	4	9·427354	2 15	10·572646	9·443479	2 16	10·556521	10·016125	2 1	9·983875	56	29
30	6	9·427582	3 23	10·572418	9·443724	3 24	10·556276	10·016142	3 2	9·983858	54	30
32	8	9·427809	4 30	10·572191	9·443968	4 32	10·556032	10·016160	4 2	9·983840	52	28
30	10	9·428036	5 38	10·571964	9·444213	5 41	10·555787	10·016177	5 3	9·983823	50	30
33	12	9·428263	6 45	10·571737	9·444458	6 49	10·555542	10·016195	6 4	9·983805	48	27
30	14	9·428490	7 53	10·571510	9·444702	7 57	10·555298	10·016212	7 4	9·983788	46	30
34	16	9·428717	8 60	10·571283	9·444947	8 65	10·555053	10·016230	8 5	9·983770	44	26
30	18	9·428944	9 68	10·571056	9·445191	9 73	10·554809	10·016248	9 5	9·983752	42	30
35	20	9·429170	10 75	10·570830	9·445435	10 81	10·554565	10·016265	10 6	9·983735	40	25
30	22	9·429397	11 83	10·570603	9·445679	11 89	10·554321	10·016283	11 6	9·983717	38	30
36	24	9·429623	12 90	10·570377	9·445923	12 97	10·554077	10·016300	12 7	9·983700	36	24
30	26	9·429849	13 98	10·570151	9·446167	13 106	10·553833	10·016318	13 8	9·983682	34	30
37	28	9·430075	14 105	10·569925	9·446411	14 114	10·553589	10·016336	14 8	9·983664	32	23
30	30	9·430301	15 113	10·569699	9·446654	15 122	10·553346	10·016353	15 9	9·983647	30	30
38	32	9·430527	16 120	10·569473	9·446898	16 130	10·553102	10·016371	16 9	9·983629	28	22
30	34	9·430752	17 128	10·569248	9·447141	17 138	10·552859	10·016389	17 10	9·983611	26	30
39	36	9·430978	18 135	10·569022	9·447384	18 146	10·552616	10·016406	18 11	9·983594	24	21
30	38	9·431203	19 143	10·568797	9·447627	19 154	10·552373	10·016424	19 11	9·983576	22	30
40	40	9·431429	20 151	10·568571	9·447870	20 162	10·552130	10·016442	20 12	9·983558	20	20
30	42	9·431654	21 158	10·568346	9·448113	21 171	10·551887	10·016460	21 12	9·983540	18	30
41	44	9·431879	22 166	10·568121	9·448356	22 179	10·551644	10·016477	22 13	9·983523	16	19
30	46	9·432104	23 173	10·567896	9·448599	23 187	10·551401	10·016495	23 14	9·983505	14	30
42	48	9·432329	24 181	10·567671	9·448841	24 195	10·551159	10·016513	24 14	9·983487	12	18
30	50	9·432553	25 188	10·567447	9·449084	25 203	10·550916	10·016531	25 15	9·983469	10	30
43	52	9·432778	26 196	10·567222	9·449326	26 211	10·550674	10·016548	26 15	9·983452	8	17
30	54	9·433002	27 203	10·566998	9·449568	27 219	10·550432	10·016566	27 16	9·983434	6	30
44	56	9·433226	28 210	10·566774	9·449810	28 227	10·550190	10·016584	28 17	9·983416	4	16
30	58	9·433451	29 217	10·566549	9·450052	29 235	10·549948	10·016602	29 17	9·983398	2	30
45	3	9·433675	30 226	10·566325	9·450294	30 244	10·549706	10·016619	30 18	9·983381	57	15
30	2	9·433898	1 7	10·566102	9·450536	1 8	10·549464	10·016637	1 1	9·983363	58	30
46	4	9·434122	2 15	10·565878	9·450777	2 16	10·549223	10·016655	2 1	9·983345	56	14
30	6	9·434346	3 22	10·565654	9·451019	3 24	10·548981	10·016673	3 2	9·983327	64	30
47	8	9·434569	4 30	10·565431	9·451260	4 32	10·548740	10·016691	4 2	9·983309	52	3
30	10	9·434793	5 37	10·565207	9·451502	5 40	10·548498	10·016709	5 3	9·983291	50	30
48	12	9·435016	6 44	10·564984	9·451743	6 48	10·548257	10·016727	6 4	9·983273	48	12
30	14	9·435239	7 52	10·564761	9·451984	7 56	10·548016	10·016744	7 4	9·983256	46	30
49	16	9·435462	8 59	10·564538	9·452225	8 64	10·547775	10·016762	8 5	9·983238	44	11
30	18	9·435685	9 67	10·564315	9·452465	9 72	10·547535	10·016780	9 5	9·983220	42	30
50	20	9·435908	10 74	10·564092	9·452706	10 80	10·547294	10·016798	10 6	9·983202	40	10
30	22	9·436131	11 82	10·563869	9·452947	11 88	10·547053	10·016816	11 7	9·983184	38	30
51	24	9·436353	12 89	10·563647	9·453187	12 96	10·546813	10·016834	12 7	9·983166	36	0
30	26	9·436576	13 97	10·563424	9·453428	13 104	10·546572	10·016852	13 8	9·983148	34	30
52	28	9·436798	14 104	10·563202	9·453668	14 112	10·546332	10·016870	14 8	9·983130	32	8
30	30	9·437020	15 111	10·562980	9·453908	15 120	10·546092	10·016888	15 9	9·983112	30	30
53	32	9·437242	16 118	10·562758	9·454148	16 128	10·545852	10·016906	16 10	9·983094	28	7
30	34	9·437464	17 126	10·562536	9·454388	17 136	10·545612	10·016924	17 10	9·983076	26	30
54	36	9·437686	18 133	10·562314	9·454628	18 144	10·545372	10·016942	18 11	9·983058	24	6
30	38	9·437908	19 141	10·562092	9·454867	19 152	10·545133	10·016960	19 11	9·983040	22	30
55	40	9·438129	20 148	10·561871	9·455107	20 160	10·544893	10·016978	20 12	9·983022	20	5
30	42	9·438351	21 156	10·561649	9·455346	21 168	10·544654	10·016996	21 13	9·983004	18	30
56	44	9·438572	22 163	10·561428	9·455586	22 176	10·544414	10·017014	22 13	9·982986	16	4
30	46	9·438793	23 171	10·561207	9·455825	23 184	10·544175	10·017032	23 14	9·982968	14	30
57	48	9·439014	24 178	10·560986	9·456064	24 192	10·543936	10·017050	24 14	9·982950	12	3
30	50	9·439235	25 185	10·560765	9·456303	25 200	10·543697	10·017068	25 15	9·982932	10	30
58	52	9·439456	26 192	10·560544	9·456542	26 208	10·543458	10·017086	26 16	7·982914	8	2
30	54	9·439677	27 200	10·560323	9·456781	27 216	10·543219	10·017104	27 16	9·982896	6	30
59	56	9·439897	28 207	10·560103	9·457019	28 224	10·542981	10·017122	28 17	9·982878	4	1
30	58	9·440118	29 215	10·559882	9·457258	29 232	10·542742	10·017140	29 17	9·982860	2	30
60	4	9·440338	30 222	10·559662	9·457496	30 240	10·542504	10·017158	30 18	9·982842	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

74° — 4h 56m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1h 4m — 16°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9.440338		10.559662	9.457496		10.542504	10.017158		9.982842	56	60
30	2	9.440558	1″ 7	10.559441	9.457735	1″ 8	10.542265	10.017176	1″ 1	9.982824	58	30
1	4	9.440778	2 15	10.559222	9.457973	2 16	10.542027	10.017195	2 1	9.982805	56	59
30	6	9.440998	3 22	10.559002	9.458211	3 24	10.541789	10.017213	3 2	9.982787	54	30
2	8	9.441218	4 29	10.558782	9.458449	4 32	10.541551	10.017231	4 2	9.982769	52	58
30	10	9.441438	5 36	10.558562	9.458687	5 39	10.541313	10.017249	5 3	9.982751	50	30
3	12	9.441658	6 44	10.558342	9.458925	6 47	10.541075	10.017267	6 4	9.982733	48	57
30	14	9.441877	7 51	10.558123	9.459163	7 55	10.540837	10.017285	7 4	9.982715	46	30
4	16	9.442096	8 58	10.557904	9.459400	8 63	10.540600	10.017304	8 5	9.982696	44	56
30	18	9.442316	9 65	10.557684	9.459638	9 71	10.540362	10.017322	9 5	9.982678	42	30
5	20	9.442535	10 73	10.557465	9.459875	10 79	10.540125	10.017340	10 6	9.982660	40	55
30	22	9.442754	11 80	10.557246	9.460112	11 87	10.539888	10.017358	11 7	9.982642	38	30
6	24	9.442973	12 87	10.557027	9.460349	12 95	10.539651	10.017376	12 7	9.982624	36	54
30	26	9.443192	13 95	10.556808	9.460586	13 103	10.539414	10.017395	13 8	9.982605	34	30
7	28	9.443410	14 102	10.556590	9.460823	14 110	10.539177	10.017413	14 9	9.982587	32	53
30	30	9.443629	15 109	10.556371	9.461060	15 118	10.538940	10.017431	15 9	9.982569	30	30
8	32	9.443847	16 116	10.556153	9.461297	16 126	10.538703	10.017449	16 10	9.982551	28	52
30	34	9.444066	17 124	10.555934	9.461533	17 134	10.538467	10.017468	17 10	9.982532	26	30
9	36	9.444284	18 131	10.555716	9.461770	18 142	10.538230	10.017486	18 11	9.982514	24	51
30	38	9.444502	19 138	10.555498	9.462006	19 150	10.537994	10.017504	19 12	9.982496	22	30
10	40	9.444720	20 146	10.555280	9.462242	20 158	10.537758	10.017523	20 12	9.982477	20	50
30	42	9.444938	21 153	10.555062	9.462478	21 166	10.537522	10.017541	21 13	9.982459	18	30
11	44	9.445155	22 160	10.554845	9.462715	22 174	10.537286	10.017559	22 13	9.982441	16	49
30	46	9.445373	23 167	10.554627	9.462950	23 181	10.537050	10.017578	23 14	9.982422	14	30
12	48	9.445590	24 175	10.554410	9.463186	24 189	10.536814	10.017596	24 15	9.982404	12	48
30	50	9.445808	25 182	10.554192	9.463422	25 197	10.536578	10.017614	25 15	9.982386	10	30
13	52	9.446025	26 189	10.553975	9.463658	26 205	10.536342	10.017633	26 16	9.982367	8	47
30	54	9.446242	27 196	10.553758	9.463893	27 213	10.536107	10.017651	27 16	9.982349	6	30
14	56	9.446459	28 204	10.553541	9.464128	28 221	10.535872	10.017669	28 17	9.982331	4	46
30	58	9.446676	29 211	10.553324	9.464364	29 229	10.535636	10.017688	29 18	9.982312	2	30
15	5	9.446893	30 218	10.553107	9.464599	30 237	10.535401	10.017706	30 18	9.982294	55	45
30	2	9.447109	1 7	10.552891	9.464834	1 8	10.535166	10.017725	1 1	9.982275	58	30
16	4	9.447326	2 14	10.552674	9.465069	2 16	10.534931	10.017743	2 1	9.982257	56	44
30	6	9.447542	3 22	10.552458	9.465304	3 23	10.534696	10.017761	3 2	9.982239	54	30
17	8	9.447759	4 29	10.552241	9.465539	4 31	10.534461	10.017780	4 2	9.982220	52	43
30	10	9.447975	5 36	10.552025	9.465773	5 39	10.534227	10.017798	5 3	9.982202	50	30
18	12	9.448191	6 43	10.551809	9.466008	6 47	10.533992	10.017817	6 4	9.982183	48	42
30	14	9.448407	7 50	10.551593	9.466242	7 54	10.533758	10.017835	7 4	9.982165	46	30
19	16	9.448623	8 57	10.551377	9.466477	8 62	10.533523	10.017854	8 5	9.982146	44	41
30	18	9.448838	9 64	10.551162	9.466711	9 70	10.533289	10.017872	9 6	9.982128	42	30
20	20	9.449054	10 72	10.550946	9.466945	10 78	10.533055	10.017891	10 6	9.982109	40	40
30	22	9.449269	11 79	10.550731	9.467179	11 86	10.532821	10.017909	11 7	9.982091	38	30
21	24	9.449485	12 86	10.550515	9.467413	12 93	10.532587	10.017928	12 7	9.982072	36	39
30	26	9.449700	13 93	10.550300	9.467647	13 101	10.532353	10.017946	13 8	9.982054	34	30
22	28	9.449915	14 100	10.550085	9.467880	14 109	10.532120	10.017965	14 9	9.982035	32	38
30	30	9.450130	15 107	10.549870	9.468114	15 117	10.531886	10.017984	15 9	9.982016	30	30
23	32	9.450345	16 114	10.549655	9.468347	16 124	10.531653	10.018002	16 10	9.981998	28	37
30	34	9.450560	17 122	10.549440	9.468581	17 132	10.531419	10.018021	17 11	9.981979	26	30
24	36	9.450775	18 129	10.549225	9.468814	18 140	10.531186	10.018039	18 11	9.981961	24	36
30	38	9.450989	19 136	10.549011	9.469047	19 148	10.530953	10.018058	19 12	9.981942	22	30
25	40	9.451204	20 143	10.548796	9.469280	20 156	10.530720	10.018076	20 12	9.981924	20	35
30	42	9.451418	21 150	10.548582	9.469513	21 163	10.530487	10.018095	21 13	9.981905	18	30
26	44	9.451632	22 157	10.548368	9.469746	22 171	10.530254	10.018114	22 14	9.981886	16	34
30	46	9.451846	23 165	10.548154	9.469979	23 179	10.530021	10.018132	23 14	9.981868	14	30
27	48	9.452060	24 172	10.547940	9.470211	24 187	10.529789	10.018151	24 15	9.981849	12	33
30	50	9.452274	25 179	10.547726	9.470444	25 194	10.529556	10.018170	25 16	9.981830	10	30
28	52	9.452488	26 186	10.547512	9.470676	26 202	10.529324	10.018188	26 16	9.981812	8	32
30	54	9.452702	27 193	10.547298	9.470909	27 210	10.529091	10.018207	27 17	9.981793	6	30
29	56	9.452915	28 200	10.547085	9.471141	28 218	10.528859	10.018226	28 17	9.981774	4	31
30	58	9.453129	29 208	10.546871	9.471373	29 226	10.528627	10.018244	29 18	9.981756	2	30
30	6	9.453342	30 215	10.546658	9.471605	30 233	10.528395	10.018263	30 19	9.981737	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

73° — 4h 54m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

$1^h\ 6^m$ — 16°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·453342		10·546658	9·471605		10·528395	10·018263		9·981737	54	30
30	2	9·453555	1″ 7	10·546445	9·471837	1″ 8	10·528163	10·018282	1″ 1	9·981718	58	30
31	4	9·453768	2 14	10·546232	9·472069	2 15	10·527931	10·018300	2 1	9·981700	56	29
30	6	9·453981	3 21	10·546019	9·472300	3 23	10·527700	10·018319	3 2	9·981681	54	30
32	8	9·454194	4 28	10·545806	9·472532	4 31	10·527468	10·018338	4 3	9·981662	52	28
30	10	9·454407	5 35	10·545593	9·472763	5 38	10·527237	10·018357	5 3	9·981643	50	30
33	12	9·454619	6 42	10·545381	9·472995	6 46	10·527005	10·018375	6 4	9·981625	48	27
30	14	9·454832	7 49	10·545168	9·473226	7 54	10·526774	10·018394	7 4	9·981606	46	30
34	16	9·455044	8 56	10·544956	9·473457	8 61	10·526543	10·018413	8 5	9·981587	44	26
30	18	9·455256	9 63	10·544744	9·473688	9 69	10·526312	10·018432	9 6	9·981568	42	30
35	20	9·455469	10 70	10·544531	9·473919	10 77	10·526081	10·018451	10 6	9·981549	40	25
30	22	9·455681	11 78	10·544319	9·474150	11 84	10·525850	10·018469	11 7	9·981531	38	30
36	24	9·455893	12 85	10·544107	9·474381	12 92	10·525619	10·018488	12 8	9·981512	36	24
30	26	9·456104	13 92	10·543896	9·474612	13 100	10·525388	10·018507	13 8	9·981493	34	30
37	28	9·456316	14 99	10·543684	9·474842	14 108	10·525158	10·018526	14 9	9·981474	32	23
30	30	9·456528	15 106	10·543472	9·475073	15 115	10·524927	10·018545	15 9	9·981455	30	30
38	32	9·456739	16 113	10·543261	9·475303	16 123	10·524697	10·018564	16 10	9·981436	28	22
30	34	9·456951	17 120	10·543049	9·475533	17 131	10·524467	10·018583	17 11	9·981417	26	30
39	36	9·457162	18 127	10·542838	9·475763	18 138	10·524237	10·018601	18 11	9·981399	24	21
30	38	9·457373	19 134	10·542627	9·475993	19 146	10·524007	10·018620	19 12	9·981380	22	30
40	40	9·457584	20 141	10·542416	9·476223	20 154	10·523777	10·018639	20 13	9·981361	20	20
30	42	9·457795	21 148	10·542205	9·476453	21 161	10·523547	10·018658	21 13	9·981342	18	30
41	44	9·458006	22 155	10·541994	9·476683	22 169	10·523317	10·018677	22 14	9·981323	16	19
30	46	9·458217	23 162	10·541783	9·476913	23 177	10·523087	10·018696	23 14	9·981304	14	30
42	48	9·458427	24 169	10·541573	9·477142	24 184	10·522858	10·018715	24 15	9·981285	12	18
30	50	9·458638	25 176	10·541362	9·477372	25 192	10·522628	10·018734	25 16	9·981266	10	30
43	52	9·458848	26 183	10·541152	9·477601	26 200	10·522399	10·018753	26 16	9·981247	8	17
30	54	9·459058	27 190	10·540942	9·477830	27 207	10·522170	10·018772	27 17	9·981228	6	30
44	56	9·459268	28 197	10·540732	9·478059	28 215	10·521941	10·018791	28 18	9·981209	4	16
30	58	9·459478	29 204	10·540522	9·478288	29 223	10·521712	10·018810	29 18	9·981190	2	30
45	7	9·459688	30 211	10·540312	9·478517	30 230	10·521483	10·018829	30 19	9·981171	53	15
30	2	9·459898	1 7	10·540102	9·478746	1 8	10·521254	10·018848	1 1	9·981152	58	30
46	4	9·460108	2 14	10·539892	9·478975	2 15	10·521025	10·018867	2 1	9·981133	56	14
30	6	9·460317	3 21	10·539683	9·479203	3 23	10·520797	10·018886	3 2	9·981114	54	30
47	8	9·460527	4 28	10·539473	9·479432	4 30	10·520568	10·018905	4 3	9·981095	52	13
30	10	9·460736	5 35	10·539264	9·479660	5 38	10·520340	10·018924	5 3	9·981076	50	30
48	12	9·460946	6 42	10·539054	9·479889	6 45	10·520111	10·018943	6 4	9·981057	48	12
30	14	9·461155	7 49	10·538845	9·480117	7 53	10·519883	10·018962	7 4	9·981038	46	30
49	16	9·461364	8 56	10·538636	9·480345	8 61	10·519655	10·018981	8 5	9·981019	44	11
30	18	9·461573	9 62	10·538427	9·480573	9 68	10·519427	10·019000	9 6	9·981000	42	30
50	20	9·461782	10 69	10·538218	9·480801	10 76	10·519199	10·019019	10 6	9·980981	40	10
30	22	9·461990	11 76	10·538010	9·481029	11 83	10·518971	10·019039	11 7	9·980901	38	30
51	24	9·462199	12 83	10·537801	9·481257	12 91	10·518743	10·019058	12 8	9·980942	36	9
30	26	9·462407	13 90	10·537593	9·481484	13 99	10·518516	10·019077	13 8	9·980923	34	30
52	28	9·462616	14 97	10·537384	9·481712	14 106	10·518288	10·019090	14 9	9·980904	32	8
30	30	9·462824	15 104	10·537176	9·481939	15 114	10·518061	10·019115	15 10	9·980885	30	30
53	32	9·463032	16 111	10·536968	9·482167	16 121	10·517833	10·019134	16 10	9·980866	28	7
30	34	9·463240	17 118	10·536760	9·482394	17 129	10·517606	10·019153	17 11	9·980847	26	30
54	36	9·463448	18 125	10·536552	9·482621	18 136	10·517379	10·019173	18 12	9·980827	24	6
30	38	9·463656	19 132	10·536344	9·482848	19 144	10·517152	10·019192	19 12	9·980808	22	30
55	40	9·463864	20 139	10·536136	9·483075	20 152	10·516925	10·019211	70 13	9·980789	20	5
30	42	9·464072	21 146	10·535928	9·483302	21 159	10·516698	10·019230	21 13	9·980770	18	30
56	44	9·464279	22 153	10·535721	9·483529	22 167	10·516471	10·019250	22 14	9·980750	16	4
30	46	9·464486	23 160	10·535514	9·483755	23 174	10·516245	10·019269	23 15	9·980731	14	30
57	48	9·464694	24 167	10·535306	9·483982	24 182	10·516018	10·019288	24 15	9·980712	12	3
30	50	9·464901	25 174	10·535099	9·484208	25 189	10·515792	10·019307	25 16	9·980693	10	30
58	52	9·465108	26 180	10·534892	9·484435	26 197	10·515565	10·019327	26 17	9·980673	8	2
30	54	9·465315	27 187	10·534685	9·484661	27 205	10·515339	10·019346	27 17	9·980654	6	30
59	56	9·465522	28 194	10·534478	9·484887	28 212	10·515113	10·019365	28 18	9·980635	4	1
30	58	9·465729	29 201	10·534271	9·485113	29 220	10·514887	10·019384	29 19	9·980616	2	30
60	8	9·465935	30 208	10·534065	9·485339	30 227	10·514661	10·019404	30 19	9·980596	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

73° — $4^h\ 52^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1h 8m — 17°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·465935		10·534065	9·485339		10·514661	10·019404		9·980596	52	60
30	2	9·466142	1″ 7	10·533858	9·485565	1″ 7	10·514435	10·019423	1″ 1	9·980577	58	30
1	4	9·466348	2 14	10·533652	9·485791	2 15	10·514209	10·019442	2 1	9·980558	56	59
30	6	9·466555	3 20	10·533445	9·486016	3 22	10·513984	10·019462	3 2	9·980538	54	30
2	8	9·466761	4 27	10·533239	9·486242	4 30	10·513758	10·019481	4 3	9·980519	52	58
30	10	9·466967	5 34	10·533033	9·486467	5 37	10·513533	10·019500	5 3	9·980500	50	30
3	12	9·467173	6 41	10·532827	9·486693	6 45	10·513307	10·019520	6 4	9·980480	48	57
30	14	9·467379	7 48	10·532621	9·486918	7 52	10·513082	10·019539	7 5	9·980461	46	30
4	16	9·467585	8 55	10·532415	9·487143	8 60	10·512857	10·019558	8 5	9·980442	44	56
30	18	9·467790	9 61	10·532210	9·487368	9 67	10·512632	10·019578	9 6	9·980422	42	30
5	20	9·467996	10 68	10·532004	9·487593	10 75	10·512407	10·019597	10 6	9·980403	40	55
30	22	9·468202	11 75	10·531798	9·487818	11 82	10·512182	10·019617	11 7	9·980383	38	30
6	24	9·468407	12 82	10·531593	9·488043	12 90	10·511957	10·019636	12 8	9·980364	36	54
30	26	9·468612	13 89	10·531388	9·488268	13 97	10·511732	10·019656	13 8	9·980344	34	30
7	28	9·468817	14 96	10·531183	9·488492	14 105	10·511508	10·019675	14 9	9·980325	32	53
30	30	9·469022	15 102	10·530978	9·488717	15 112	10·511283	10·019694	15 10	9·980306	30	30
8	32	9·469227	16 109	10·530773	9·488941	16 120	10·511059	10·019714	16 10	9·980286	28	52
30	34	9·469432	17 116	10·530568	9·489166	17 127	10·510834	10·019733	17 11	9·980267	26	30
9	36	9·469637	18 123	10·530363	9·489390	18 135	10·510610	10·019753	18 12	9·980247	24	51
30	38	9·469842	19 130	10·530158	9·489614	19 142	10·510386	10·019772	19 12	9·980228	22	30
10	40	9·470046	20 137	10·529954	9·489838	20 150	10·510162	10·019792	20 13	9·980208	20	50
30	42	9·470251	21 143	10·529749	9·490062	21 157	10·509938	10·019811	21 14	9·980189	18	30
11	44	9·470455	22 150	10·529545	9·490286	22 165	10·509714	10·019831	22 14	9·980169	16	49
30	46	9·470659	23 157	10·529341	9·490510	23 172	10·509490	10·019851	23 15	9·980149	14	30
12	48	9·470863	24 164	10·529137	9·490733	24 180	10·509267	10·019870	24 16	9·980130	12	48
30	50	9·471067	25 171	10·528933	9·490957	25 187	10·509043	10·019890	25 16	9·980110	10	30
13	52	9·471271	26 178	10·528729	9·491180	26 194	10·508820	10·019909	26 17	9·980091	8	47
30	54	9·471475	27 184	10·528525	9·491404	27 202	10·508596	10·019929	27 18	9·980071	6	30
14	56	9·471679	28 191	10·528321	9·491627	28 209	10·508373	10·019948	28 18	9·980052	4	46
30	58	9·471882	29 198	10·528118	9·491850	29 217	10·508150	10·019968	29 19	9·980032	2	30
15	9	9·472086	30 205	10·527914	9·492073	30 224	10·507927	10·019988	30 19	9·980012	51	45
30	2	9·472289	1 7	10·527711	9·492296	1 7	10·507704	10·020007	1 1	9·979993	58	30
16	4	9·472492	2 13	10·527508	9·492519	2 15	10·507481	10·020027	2 1	9·979973	56	44
30	6	9·472695	3 20	10·527305	9·492742	3 22	10·507258	10·020046	3 2	9·979954	54	30
17	8	9·472898	4 27	10·527102	9·492965	4 30	10·507035	10·020066	4 3	9·979934	52	43
30	10	9·473101	5 34	10·526899	9·493187	5 37	10·506813	10·020086	5 3	9·979914	50	30
18	12	9·473304	6 40	10·526696	9·493410	6 44	10·506590	10·020105	6 4	9·979895	48	42
30	14	9·473507	7 47	10·526493	9·493632	7 52	10·506368	10·020125	7 5	9·979875	46	30
19	16	9·473710	8 54	10·526290	9·493854	8 59	10·506146	10·020145	8 5	9·979855	44	41
30	18	9·473912	9 61	10·526088	9·494077	9 66	10·505923	10·020164	9 6	9·979836	42	30
20	20	9·474115	10 67	10·525885	9·494299	10 74	10·505701	10·020184	10 7	9·979816	40	40
30	22	9·474317	11 74	10·525683	9·494521	11 81	10·505479	10·020204	11 7	9·979796	38	30
21	24	9·474519	12 81	10·525481	9·494743	12 89	10·505257	10·020224	12 8	9·979776	36	39
30	26	9·474721	13 88	10·525279	9·494965	13 96	10·505035	10·020243	13 9	9·979757	34	30
22	28	9·474923	14 94	10·525077	9·495186	14 103	10·504814	10·020263	14 9	9·979737	32	38
30	30	9·475125	15 101	10·524875	9·495408	15 111	10·504592	10·020283	15 10	9·979717	30	30
23	32	9·475327	16 108	10·524673	9·495630	16 118	10·504370	10·020303	16 11	9·979697	28	37
30	34	9·475529	17 115	10·524471	9·495851	17 126	10·504149	10·020322	17 11	9·979678	26	30
24	36	9·475730	18 122	10·524270	9·496073	18 133	10·503927	10·020342	18 12	9·979658	24	36
30	38	9·475932	19 128	10·524068	9·496294	19 140	10·503706	10·020362	19 13	9·979638	22	30
25	40	9·476133	20 135	10·523867	9·496515	20 148	10·503485	10·020382	20 13	9·979618	20	35
30	42	9·476335	21 142	10·523665	9·496736	21 155	10·503264	10·020402	21 14	9·979598	18	30
26	44	9·476536	22 149	10·523464	9·496957	22 163	10·503043	10·020421	22 15	9·979579	16	34
30	46	9·476737	23 155	10·523263	9·497178	23 170	10·502822	10·020441	23 15	9·979559	14	30
27	48	9·476938	24 161	10·523062	9·497399	24 177	10·502601	10·020461	24 16	9·979539	12	33
30	50	9·477139	25 168	10·522861	9·497620	25 185	10·502380	10·020481	25 16	9·979519	10	30
28	52	9·477340	26 175	10·522660	9·497841	26 192	10·502159	10·020501	26 17	9·979499	8	32
30	54	9·477540	27 181	10·522460	9·498061	27 200	10·501939	10·020521	27 18	9·979479	6	30
29	56	9·477741	28 188	10·522259	9·498282	28 207	10·501718	10·020541	28 18	9·979459	4	31
30	58	9·477941	29 195	10·522059	9·498502	29 214	10·501498	10·020561	29 19	9·979439	2	30
30	10	9·478142	30 202	10·521858	9·498722	30 222	10·501278	10·020580	30 20	9·979420	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

72° — 4h 50m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1ʰ 10ᵐ — 17°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·478142		10·521858	9·498722		10·501278	10·020580		9·979420	60	30
30	2	9·478342	1″ 7	10·521658	9·498943	1″ 7	10·501057	10·020600	1″ 1	9·979400	58	30
31	4	9·478542	2 13	10·521458	9·499163	2 15	10·500837	10·020620	2 1	9·979380	56	29
30	6	9·478742	3 20	10·521258	9·499383	3 22	10·500617	10·020640	3 2	9·979360	54	30
32	8	9·478942	4 26	10·521058	9·499603	4 29	10·500397	10·020660	4 3	9·979340	52	28
30	10	9·479142	5 33	10·520858	9·499822	5 36	10·500178	10·020680	5 3	9·979320	50	30
33	12	9·479342	6 40	10·520658	9·500042	6 44	10·499958	10·020700	6 4	9·979300	48	27
30	14	9·479542	7 46	10·520458	9·500262	7 51	10·499738	10·020720	7 5	9·979280	46	30
34	16	9·479741	8 53	10·520259	9·500481	8 58	10·499519	10·020740	8 5	9·979260	44	26
30	18	9·479941	9 60	10·520059	9·500701	9 66	10·499299	10·020760	9 6	9·979240	42	30
35	20	9·480140	10 66	10·519860	9·500920	10 73	10·499080	10·020780	10 7	9·979220	40	25
30	22	9·480339	11 73	10·519661	9·501140	11 80	10·498860	10·020800	11 7	9·979200	38	30
36	24	9·480539	12 80	10·519461	9·501359	12 88	10·498641	10·020820	12 8	9·979180	36	24
30	26	9·480738	13 86	10·519262	9·501578	13 95	10·498422	10·020840	13 9	9·979160	34	30
37	28	9·480937	14 93	10·519063	9·501797	14 102	10·498203	10·020860	14 9	9·979140	32	23
30	30	9·481135	15 99	10·518865	9·502016	15 109	10·497984	10·020880	15 10	9·979120	30	30
38	32	9·481334	16 106	10·518666	9·502235	16 117	10·497765	10·020900	16 11	9·979100	28	22
30	34	9·481533	17 113	10·518467	9·502453	17 124	10·497547	10·020921	17 11	9·979079	26	30
39	36	9·481731	18 119	10·518269	9·502672	18 131	10·497328	10·020941	18 12	9·979059	24	21
30	38	9·481930	19 126	10·518070	9·502891	19 139	10·497109	10·020961	19 13	9·979039	22	30
40	40	9·482128	20 132	10·517872	9·503109	20 146	10·496891	10·020981	20 13	9·979019	20	20
30	42	9·482327	21 139	10·517673	9·503328	21 153	10·496672	10·021001	21 14	9·978999	18	30
41	44	9·482525	22 146	10·517475	9·503546	22 161	10·496454	10·021021	22 15	9·978979	16	19
30	46	9·482723	23 152	10·517277	9·503764	23 168	10·496236	10·021041	23 15	9·978959	14	30
42	48	9·482921	24 159	10·517079	9·503982	24 175	10·496018	10·021061	24 16	9·978939	12	18
30	50	9·483119	25 166	10·516881	9·504200	25 182	10·495800	10·021082	25 17	9·978918	10	30
43	52	9·483316	26 172	10·516684	9·504418	26 190	10·495582	10·021102	26 17	9·978898	8	17
30	54	9·483514	27 179	10·516486	9·504636	27 197	10·495364	10·021122	27 18	9·978878	6	30
44	56	9·483712	28 186	10·516288	9·504854	28 204	10·495146	10·021142	28 19	9·978858	4	16
30	58	9·483909	29 192	10·516091	9·505072	29 212	10·494928	10·021162	29 19	9·978838	2	30
45	[illegible]	9·484107	30 199	10·515893	9·505289	30 219	10·494711	10·021183	30 20	9·978817	[illegible]	15
30	2	9·484304	1 7	10·515696	9·505507	1 7	10·494493	10·021203	1 1	9·978797	58	30
46	4	9·484501	2 13	10·515499	9·505724	2 14	10·494276	10·021223	2 1	9·978777	56	14
30	6	9·484698	3 20	10·515302	9·505941	3 22	10·494059	10·021243	3 2	9·978757	54	30
47	8	9·484895	4 26	10·515105	9·506159	4 29	10·493841	10·021263	4 3	9·978737	52	13
30	10	9·485092	5 33	10·514908	9·506376	5 36	10·493624	10·021284	5 3	9·978716	50	30
48	12	9·485289	6 39	10·514711	9·506593	6 43	10·493407	10·021304	6 4	9·978696	48	12
30	13	9·485485	7 46	10·514515	9·506810	7 50	10·493190	10·021324	7 5	9·978676	46	30
49	16	9·485682	8 52	10·514318	9·507027	8 58	10·492973	10·021345	8 5	9·978655	44	11
30	18	9·485879	9 59	10·514121	9·507243	9 65	10·492757	10·021365	9 6	9·978635	42	30
50	20	9·486075	10 65	10·513925	9·507460	10 72	10·492540	10·021385	10 7	9·978615	40	10
30	22	9·486271	11 72	10·513729	9·507677	11 79	10·492323	10·021406	11 7	9·978594	38	30
51	24	9·486467	12 78	10·513533	9·507893	12 87	10·492107	10·021426	12 8	9·978574	36	9
30	26	9·486664	13 85	10·513336	9·508110	13 94	10·491890	10·021446	13 9	9·978554	34	30
52	28	9·486860	14 91	10·513140	9·508326	14 101	10·491674	10·021467	14 10	9·978533	32	8
30	30	9·487055	15 98	10·512945	9·508542	15 108	10·491458	10·021487	15 10	9·978513	30	30
53	32	9·487251	16 104	10·512749	9·508759	16 115	10·491241	10·021507	16 11	9·978493	28	7
30	34	9·487447	17 111	10·512553	9·508975	17 123	10·491025	10·021528	17 12	9·978472	26	30
54	36	9·487643	18 117	10·512357	9·509191	18 130	10·490809	10·021548	18 12	9·978452	24	6
30	38	9·487838	19 124	10·512162	9·509407	19 137	10·490593	10·021569	19 13	9·978431	22	30
55	40	9·488034	20 131	10·511966	9·509622	20 144	10·490378	10·021589	20 14	9·978411	20	5
30	42	9·488229	21 137	10·511771	9·509838	21 151	10·490162	10·021609	21 14	9·978391	18	30
56	44	9·488424	22 144	10·511576	9·510054	22 159	10·489946	10·021630	22 15	9·978370	16	4
30	46	9·488619	23 150	10·511381	9·510269	23 166	10·489731	10·021650	23 16	9·978350	14	30
57	48	9·488814	24 157	10·511186	9·510485	24 173	10·489515	10·021671	24 16	9·978329	12	3
30	50	9·489009	25 163	10·510991	9·510700	25 180	10·489300	10·021691	25 17	9·978309	10	30
58	52	9·489204	26 170	10·510796	9·510916	26 187	10·489084	10·021712	26 18	9·978288	8	2
30	54	9·489399	27 176	10·510601	9·511131	27 195	10·488869	10·021732	27 18	9·978268	6	30
59	56	9·489593	28 183	10·510407	9·511346	28 202	10·488654	10·021753	28 19	9·978247	4	1
30	58	9·489788	29 189	10·510212	9·511561	29 209	10·488439	10·021773	29 20	9·978227	2	30
60	[illegible]	9·489982	30 196	10·510018	9·511776	30 216	10·488224	10·021794	30 20	9·978206	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

72° — 4ʰ 48ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

$1^h\ 12^m$ — 18°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·489982		10·510018	9·511776		10·488224	10·021794		9·978206	48	60
30	2	9·490177	1″ 6	10·509823	9·511991	1″ 7	10·488009	10·021814	1″ 1	9·978186	58	30
1	4	9·490371	2 13	10·509629	9·512206	2 14	10·487794	10·021835	2 1	9·978165	56	59
30	6	9·490565	3 19	10·509435	9·512420	3 21	10·487580	10·021855	3 2	9·978145	54	30
2	8	9·490759	4 26	10·509241	9·512635	4 28	10·487365	10·021876	4 3	9·978124	52	58
30	10	9·490953	5 32	10·509047	9·512850	5 36	10·487150	10·021896	5 3	9·978104	50	30
3	12	9·491147	6 39	10·508853	9·513064	6 43	10·486936	10·021917	6 4	9·978083	48	57
30	14	9·491341	7 45	10·508659	9·513278	7 50	10·486722	10·021938	7 5	9·978062	46	30
4	16	9·491535	8 51	10·508465	9·513493	8 57	10·486507	10·021958	8 6	9·978042	44	56
30	18	9·491728	9 58	10·508272	9·513707	9 64	10·486293	10·021979	9 6	9·978021	42	30
5	20	9·491922	10 64	10·508078	9·513921	10 71	10·486079	10·021999	10 7	9·978001	40	55
30	22	9·492115	11 71	10·507885	9·514135	11 78	10·485865	10·022020	11 8	9·977980	38	30
6	24	9·492308	12 77	10·507692	9·514349	12 85	10·485651	10·022041	12 8	9·977959	36	54
30	26	9·492502	13 84	10·507498	9·514563	13 93	10·485437	10·022061	13 9	9·977939	34	30
7	28	9·492695	14 90	10·507305	9·514777	14 100	10·485223	10·022082	14 10	9·977918	32	53
30	30	9·492888	15 96	10·507112	9·514990	15 107	10·485010	10·022103	15 10	9·977897	30	30
8	32	9·493081	16 103	10·506919	9·515204	16 114	10·484796	10·022123	16 11	9·977877	28	52
30	34	9·493273	17 109	10·506727	9·515417	17 121	10·484583	10·022144	17 12	9·977856	26	30
9	36	9·493466	18 116	10·506534	9·515631	18 128	10·484369	10·022165	18 12	9·977835	24	51
30	38	9·493659	19 122	10·506341	9·515844	19 135	10·484156	10·022185	19 13	9·977815	22	30
10	40	9·493851	20 129	10·506149	9·516057	20 142	10·483943	10·022206	20 14	9·977794	20	50
30	42	9·494044	21 135	10·505956	9·516271	21 150	10·483729	10·022227	21 14	9·977773	18	30
11	44	9·494236	22 142	10·505764	9·516484	22 157	10·483516	10·022248	22 15	9·977752	16	49
30	46	9·494428	23 148	10·505572	9·516697	23 164	10·483303	10·022268	23 16	9·977732	14	30
12	48	9·494621	24 155	10·505379	9·516910	24 171	10·483090	10·022289	24 17	9·977711	12	48
30	50	9·494813	25 161	10·505187	9·517123	25 178	10·482877	10·022310	25 17	9·977690	10	30
13	52	9·495005	26 168	10·504995	9·517335	26 185	10·482665	10·022331	26 18	9·977669	8	47
30	54	9·495196	27 174	10·504804	9·517548	27 192	10·482452	10·022352	27 19	9·977648	6	30
14	56	9·495388	28 180	10·504612	9·517761	28 199	10·482239	10·022372	28 19	9·977628	4	46
30	58	9·495580	29 186	10·504420	9·517973	29 206	10·482027	10·022393	29 20	9·977607	2	30
15	13	9·495772	30 193	10·504228	9·518186	30 214	10·481814	10·022414	30 21	9·977586	47	45
30	2	9·495963	1 6	10·504037	9·518398	1 7	10·481602	10·022435	1 1	9·977565	58	30
16	4	9·496154	2 13	10·503846	9·518610	2 14	10·481390	10·022456	2 1	9·977544	56	44
30	6	9·496346	3 19	10·503654	9·518822	3 21	10·481178	10·022476	3 2	9·977524	54	30
17	8	9·496537	4 25	10·503463	9·519034	4 28	10·480966	10·022497	4 3	9·977503	52	43
30	10	9·496728	5 32	10·503272	9·519246	5 35	10·480754	10·022518	5 3	9·977482	50	30
18	12	9·496919	6 38	10·503081	9·519458	6 42	10·480542	10·022539	6 4	9·977461	48	42
30	14	9·497110	7 44	10·502890	9·519670	7 49	10·480330	10·022560	7 5	9·977440	46	30
19	16	9·497301	8 51	10·502699	9·519882	8 56	10·480118	10·022581	8 6	9·977419	44	41
30	18	9·497492	9 57	10·502508	9·520094	9 63	10·479906	10·022602	9 6	9·977398	42	30
20	20	9·497682	10 63	10·502318	9·520305	10 70	10·479695	10·022623	10 7	9·977377	40	40
30	22	9·497873	11 70	10·502127	9·520517	11 77	10·479483	10·022644	11 8	9·977356	38	30
21	24	9·498064	12 76	10·501936	9·520728	12 84	10·479272	10·022665	12 8	9·977335	36	39
30	26	9·498254	13 82	10·501746	9·520939	13 91	10·479061	10·022686	13 9	9·977314	34	30
22	28	9·498444	14 89	10·501556	9·521151	14 98	10·478849	10·022707	14 10	9·977293	32	38
30	30	9·498634	15 95	10·501366	9·521362	15 105	10·478638	10·022728	15 10	9·977272	30	30
23	32	9·498825	16 101	10·501175	9·521573	16 112	10·478427	10·022749	16 11	9·977251	28	37
30	34	9·499015	17 108	10·500985	9·521784	17 120	10·478216	10·022770	17 12	9·977230	26	30
24	36	9·499204	18 114	10·500796	9·521995	18 127	10·478005	10·022791	18 13	9·977209	24	36
30	38	9·499394	19 121	10·500606	9·522206	19 134	10·477794	10·022812	19 13	9·977188	22	30
25	40	9·499584	20 127	10·500416	9·522417	20 141	10·477583	10·022833	20 14	9·977167	20	35
30	42	9·499774	21 133	10·500226	9·522627	21 148	10·477373	10·022854	21 15	9·977146	18	30
26	44	9·499963	22 140	10·500037	9·522838	22 155	10·477162	10·022875	22 15	9·977125	16	34
30	46	9·500153	23 146	10·499847	9·523048	23 162	10·476952	10·022896	23 16	9·977104	14	30
27	48	9·500342	24 152	10·499658	9·523259	24 169	10·476741	10·022917	24 17	9·977083	12	33
30	50	9·500531	25 159	10·499469	9·523469	25 176	10·476531	10·022938	25 17	9·977062	10	30
28	52	9·500721	26 165	10·499279	9·523680	26 183	10·476320	10·022959	26 18	9·977041	8	32
30	54	9·500910	27 171	10·499090	9·523890	27 190	10·476110	10·022980	27 19	9·977020	6	30
29	56	9·501099	28 178	10·498901	9·524100	28 197	10·475900	10·023001	28 20	9·976999	4	31
30	58	9·501288	29 184	10·498712	9·524310	29 204	10·475690	10·023022	29 20	9·976978	2	30
30	14	9·501476	30 190	10·498524	9·524520	30 211	10·475480	10·023043	30 21	9·976957	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

71° — $4^h\ 46^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1h 14m — 18°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·501476		10·498524	9·524520		10·475480	10·023043		9·976957	46	30
30	2	9·501665	1″ 6	10·498335	9·524730	1″ 7	10·475270	10·023065	1″ 1	9·976935	58	30
31	4	9·501854	2 12	10·498146	9·524940	2 14	10·475060	10·023086	2 1	9·976914	56	29
30	6	9·502042	3 19	10·497958	9·525149	3 21	10·474851	10·023107	3 2	9·976893	54	30
32	8	9·502231	4 25	10·497769	9·525359	4 28	10·474641	10·023128	4 3	9·976872	52	28
30	10	9·502419	5 31	10·497581	9·525568	5 35	10·474432	10·023149	5 4	9·976851	50	30
33	12	9·502607	6 37	10·497393	9·525778	6 42	10·474222	10·023170	6 4	9·976830	48	27
30	14	9·502796	7 44	10·497204	9·525987	7 49	10·474013	10·023192	7 5	9·976808	46	30
34	16	9·502984	8 50	10·497016	9·526197	8 56	10·473803	10·023213	8 6	9·976787	44	26
30	18	9·503172	9 56	10·496828	9·526406	9 63	10·473594	10·023234	9 6	9·976766	42	30
35	20	9·503360	10 62	10·496640	9·526615	10 70	10·473385	10·023255	10 7	9·976745	40	25
30	22	9·503548	11 69	10·496452	9·526824	11 77	10·473176	10·023277	11 8	9·976723	38	30
36	24	9·503735	12 75	10·496265	9·527033	12 84	10·472967	10·023298	12 9	9·976702	36	24
30	26	9·503923	13 81	10·496077	9·527242	13 90	10·472758	10·023319	13 9	9·976681	34	30
37	28	9·504110	14 87	10·495890	9·527451	14 97	10·472549	10·023340	14 10	9·976660	32	23
30	30	9·504298	15 94	10·495702	9·527660	15 104	10·472340	10·023362	15 11	9·976638	30	30
38	32	9·504485	16 100	10·495515	9·527868	16 111	10·472132	10·023383	16 11	9·976617	28	22
30	34	9·504673	17 106	10·495327	9·528077	17 118	10·471923	10·023404	17 12	9·976596	26	30
39	36	9·504860	18 112	10·495140	9·528285	18 125	10·471715	10·023426	18 13	9·976574	24	21
30	38	9·505047	19 119	10·494953	9·528494	19 132	10·471506	10·023447	19 13	9·976553	22	30
40	40	9·505234	20 125	10·494766	9·528702	20 139	10·471298	10·023468	20 14	9·976532	20	20
30	42	9·505421	21 131	10·494579	9·528910	21 146	10·471090	10·023490	21 15	9·976510	18	30
41	44	9·505608	22 137	10·494392	9·529119	22 153	10·470881	10·023511	22 16	9·976489	16	19
30	46	9·505794	23 144	10·494206	9·529327	23 160	10·470673	10·023532	23 16	9·976468	14	30
42	48	9·505981	24 150	10·494019	9·529535	24 167	10·470465	10·023554	24 17	9·976446	12	18
30	50	9·506168	25 156	10·493832	9·529743	25 174	10·470257	10·023575	25 18	9·976425	10	30
43	52	9·506354	26 162	10·493646	9·529951	26 181	10·470049	10·023596	26 18	9·976404	8	17
30	54	9·506541	27 169	10·493459	9·530158	27 188	10·469842	10·023618	27 19	9·976382	6	30
44	56	9·506727	28 175	10·493273	9·530366	28 195	10·469634	10·023639	28 20	9·976361	4	16
30	58	9·506913	29 181	10·493087	9·530574	29 202	10·469426	10·023661	29 21	9·976339	2	30
45	15	9·507099	30 187	10·492901	9·530781	30 209	10·469219	10·023682	30 21	9·976318	45	15
30	2	9·507285	1 6	10·492715	9·530989	1 7	10·469011	10·023704	1 1	9·976296	58	30
46	4	9·507471	2 12	10·492529	9·531196	2 14	10·468804	10·023725	2 1	9·976275	56	14
30	6	9·507657	3 18	10·492343	9·531403	3 21	10·468597	10·023746	3 2	9·976254	54	30
47	8	9·507843	4 25	10·492157	9·531611	4 28	10·468389	10·023768	4 3	9·976232	52	13
30	10	9·508028	5 31	10·491972	9·531818	5 34	10·468182	10·023789	5 4	9·976211	50	30
48	12	9·508214	6 37	10·491786	9·532025	6 41	10·467975	10·023811	6 4	9·976189	48	12
30	14	9·508400	7 43	10·491600	9·532232	7 48	10·467768	10·023832	7 5	9·976168	46	30
49	16	9·508585	8 49	10·491415	9·532439	8 55	10·467561	10·023854	8 6	9·976146	44	11
30	18	9·508770	9 55	10·491230	9·532646	9 62	10·467354	10·023875	9 6	9·976125	42	30
50	20	9·508956	10 62	10·491044	9·532853	10 69	10·467147	10·023897	10 7	9·976103	40	10
30	22	9·509141	11 68	10·490859	9·533059	11 76	10·466941	10·023919	11 8	9·976081	38	30
51	24	9·509326	12 74	10·490674	9·533266	12 83	10·466734	10·023940	12 9	9·976060	36	9
30	26	9·509511	13 80	10·490489	9·533472	13 89	10·466528	10·023962	13 9	9·976038	34	30
52	28	9·509696	14 86	10·490304	9·533679	14 96	10·466321	10·023983	14 10	9·976017	32	8
30	30	9·509880	15 92	10·490120	9·533885	15 103	10·466115	10·024005	15 11	9·975995	30	30
53	32	9·510065	16 99	10·489935	9·534092	16 110	10·465908	10·024026	16 12	9·975974	28	7
30	34	9·510250	17 105	10·489750	9·534298	17 117	10·465702	10·024048	17 12	9·975952	26	30
54	36	9·510434	18 111	10·489566	9·534504	18 124	10·465496	10·024070	18 13	9·975930	24	6
30	38	9·510619	19 117	10·489381	9·534710	19 131	10·465290	10·024091	19 14	9·975909	22	30
55	40	9·510803	20 123	10·489197	9·534916	20 138	10·465084	10·024113	20 14	9·975887	20	5
30	42	9·510987	21 129	10·489013	9·535122	21 144	10·464878	10·024135	21 15	9·975865	18	30
56	44	9·511172	22 135	10·488828	9·535328	22 151	10·464672	10·024156	22 16	9·975844	16	4
30	46	9·511356	23 142	10·488644	9·535534	23 158	10·464466	10·024178	23 17	9·975822	14	30
57	48	9·511540	24 148	10·488460	9·535739	24 165	10·464261	10·024200	24 17	9·975800	12	3
30	50	9·511724	25 154	10·488276	9·535945	25 172	10·464055	10·024221	25 18	9·975779	10	30
58	52	9·511907	26 160	10·488093	9·536150	26 178	10·463850	10·024243	26 19	9·975757	8	2
30	54	9·512091	27 166	10·487909	9·536356	27 186	10·463644	10·024265	27 19	9·975735	6	30
59	56	9·512275	28 172	10·487725	9·536561	28 193	10·463439	10·024286	28 20	9·975714	4	1
30	58	9·512458	29 179	10·487542	9·536767	29 200	10·463233	10·024308	29 21	9·975692	2	30
60	16	9·512642	30 185	10·487358	9·536972	30 206	10·463028	10·024330	30 22	9·975670	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

71° — 4h 44m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1ʰ 16ᵐ — 19°

′ ″	m.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m.	′ ″
0	0	9·512642		10·487358	9·536972		10·463028	10·024330		9·975670	44	60
30	2	9·512825	1″ 6	10·487175	9·537177	1″ 7	10·462823	10·024352	1″ 1	9·975648	58	30
1	4	9·513009	2 12	10·486991	9·537382	2 14	10·462618	10·024373	2 1	9·975627	56	59
30	6	9·513192	3 18	10·486808	9·537587	3 20	10·462413	10·024395	3 2	9·975605	54	30
2	8	9·513375	4 24	10·486625	9·537792	4 27	10·462208	10·024417	4 3	9·975583	52	58
30	10	9·513558	5 30	10·486442	9·537997	5 34	10·462003	10·024439	5 4	9·975561	50	30
3	12	9·513741	6 36	10·486259	9·538202	6 41	10·461798	10·024461	6 4	9·975539	48	57
30	14	9·513924	7 43	10·486076	9·538406	7 48	10·461594	10·024482	7 5	9·975518	46	30
4	16	9·514107	8 49	10·485893	9·538611	8 54	10·461389	10·024504	8 6	9·975496	44	56
30	18	9·514289	9 55	10·485711	9·538816	9 61	10·461184	10·024526	9 7	9·975474	42	30
5	20	9·514472	10 61	10·485528	9·539020	10 68	10·460980	10·024548	10 7	9·975452	40	55
30	22	9·514655	11 67	10·485345	9·539224	11 75	10·460776	10·024570	11 8	9·975430	38	30
6	24	9·514837	12 73	10·485163	9·539429	12 82	10·460571	10·024592	12 9	9·975408	36	54
30	26	9·515019	13 79	10·484981	9·539633	13 88	10·460367	10·024614	13 9	9·975386	34	30
7	28	9·515202	14 85	10·484798	9·539837	14 95	10·460163	10·024635	14 10	9·975365	32	53
30	30	9·515384	15 91	10·484616	9·540041	15 102	10·459959	10·024657	15 11	9·975343	30	30
8	32	9·515566	16 97	10·484434	9·540245	16 109	10·459755	10·024679	16 12	9·975321	28	52
30	34	9·515748	17 103	10·484252	9·540449	17 116	10·459551	10·024701	17 12	9·975299	26	30
9	36	9·515930	18 109	10·484070	9·540653	18 122	10·459347	10·024723	18 13	9·975277	24	51
30	38	9·516112	19 115	10·483888	9·540857	19 129	10·459143	10·024745	19 14	9·975255	22	30
10	40	9·516294	20 121	10·483706	9·541061	20 136	10·458939	10·024767	20 15	9·975233	20	50
30	42	9·516475	21 127	10·483525	9·541264	21 143	10·458736	10·024789	21 15	9·975211	18	30
11	44	9·516657	22 134	10·483343	9·541468	22 150	10·458532	10·024811	22 16	9·975189	16	49
30	46	9·516838	23 140	10·483162	9·541671	23 156	10·458329	10·024833	23 17	9·975167	14	30
12	48	9·517020	24 146	10·482980	9·541875	24 163	10·458125	10·024855	24 18	9·975145	12	48
30	50	9·517201	25 152	10·482799	9·542078	25 170	10·457922	10·024877	25 18	9·975123	10	30
13	52	9·517382	26 158	10·482618	9·542281	26 177	10·457719	10·024899	26 19	9·975101	8	47
30	54	9·517564	27 164	10·482436	9·542485	27 184	10·457515	10·024921	27 20	9·975079	6	30
14	56	9·517745	28 170	10·482255	9·542688	28 190	10·457312	10·024943	28 20	9·975057	4	46
30	58	9·517926	29 176	10·482074	9·542891	29 197	10·457109	10·024965	29 21	9·975035	2	30
15	**17**	9·518107	30 182	10·481893	9·543094	30 204	10·456906	10·024987	30 22	9·975013	**43**	45
30	2	9·518287	1 6	10·481713	9·543297	1 7	10·456703	10·025009	1 1	9·974991	58	30
16	4	9·518468	2 12	10·481532	9·543499	2 13	10·456501	10·025031	2 1	9·974969	56	44
30	6	9·518649	3 18	10·481351	9·543702	3 20	10·456298	10·025053	3 2	9·974947	54	30
17	8	9·518829	4 24	10·481171	9·543905	4 27	10·456095	10·025075	4 3	9·974925	52	43
30	10	9·519010	5 30	10·480990	9·544107	5 34	10·455893	10·025098	5 4	9·974903	50	30
18	12	9·519190	6 36	10·480810	9·544310	6 40	10·455690	10·025120	6 4	9·974880	48	42
30	14	9·519371	7 42	10·480629	9·544512	7 47	10·455488	10·025142	7 5	9·974858	46	30
19	16	9·519551	8 48	10·480449	9·544715	8 54	10·455285	10·025164	8 6	9·974836	44	41
30	18	9·519731	9 54	10·480269	9·544917	9 61	10·455083	10·025186	9 7	9·974814	42	30
20	20	9·519911	10 60	10·480089	9·545119	10 67	10·454881	10·025208	10 7	9·974792	40	40
30	22	9·520091	11 66	10·479909	9·545322	11 74	10·454678	10·025230	11 8	9·974770	38	30
21	24	9·520271	12 72	10·479729	9·545524	12 81	10·454476	10·025252	12 9	9·974748	36	39
30	26	9·520451	13 78	10·479549	9·545726	13 87	10·454274	10·025275	13 10	9·974725	34	30
22	28	9·520631	14 84	10·479369	9·545928	14 94	10·454072	10·025297	14 10	9·974703	32	38
30	30	9·520810	15 90	10·479190	9·546129	15 101	10·453871	10·025319	15 11	9·974681	30	30
23	32	9·520990	16 96	10·479010	9·546331	16 108	10·453669	10·025341	16 12	9·974659	28	37
30	34	9·521169	17 102	10·478831	9·546533	17 114	10·453467	10·025364	17 13	9·974636	26	30
24	36	9·521349	18 108	10·478651	9·546735	18 121	10·453265	10·025386	18 13	9·974614	24	36
30	38	9·521528	19 114	10·478472	9·546936	19 128	10·453064	10·025408	19 14	9·974592	22	30
25	40	9·521707	20 120	10·478293	9·547138	20 135	10·452862	10·025430	20 15	9·974570	20	35
30	42	9·521887	21 126	10·478113	9·547339	21 141	10·452661	10·025453	21 16	9·974547	18	30
26	44	9·522066	22 132	10·477934	9·547540	22 148	10·452460	10·025475	22 16	9·974525	16	34
30	46	9·522245	23 138	10·477755	9·547742	23 155	10·452258	10·025497	23 17	9·574503	14	30
27	48	9·522424	24 144	10·477576	9·547943	24 162	10·452057	10·025519	24 18	9·974481	12	33
30	50	9·522602	25 150	10·477398	9·548144	25 169	10·451856	10·025542	25 18	9·974458	10	30
28	52	9·522781	26 156	10·477219	9·548345	26 175	10·451655	10·025564	26 19	9·974436	8	32
30	54	9·522960	27 162	10·477040	9·548546	27 182	10·451454	10·025586	27 20	9·974414	6	30
29	56	9·523138	28 168	10·476862	9·548747	28 188	10·451253	10·025609	28 21	9·974391	4	31
30	58	9·523317	29 174	10·476683	9·548948	29 195	10·451052	10·025631	29 21	9·974369	2	30
30	**18**	9·523495	30 180	10·476505	9·549149	30 202	10·450851	10·025653	30 22	9·974347	0	30
′ ″	m.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m.	″ ′

70° — 4ʰ 42ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1h 18m — 19°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·523495		10·476505	9·549149		10·450851	10·025653	·	9·974347	42	30
30	2	9·523674	1″ 6	10·476326	9·549349	1″ 7	10·450651	10·025676	1″ 1	9·974324	58	30
31	4	9·523852	2 12	10·476148	9·549550	2 13	10·450450	10·025698	2 1	9·974302	56	29
30	6	9·524030	3 18	10·475970	9·549751	3 20	10·450249	10·025721	3 2	9·974279	54	30
32	8	9·524208	4 24	10·475792	9·549951	4 27	10·450049	10·025743	4 3	9·974257	52	28
30	10	9·524386	5 30	10·475614	9·550152	5 33	10·449848	10·025765	5 4	9·974235	50	30
33	12	9·524564	6 35	10·475436	9·550352	6 40	10·449648	10·025788	6 4	9·974212	48	27
30	14	9·524742	7 41	10·475258	9·550552	7 47	10·449448	10·025810	7 5	9·974190	46	30
34	16	9·524920	8 47	10·475080	9·550752	8 53	10·449248	10·025833	8 6	9·974167	44	26
30	18	9·525097	9 53	10·474903	9·550952	9 60	10·449048	10·025855	9 7	9·974145	42	30
35	20	9·525275	10 59	10·474725	9·551153	10 66	10·448847	10·025878	10 7	9·974122	40	25
30	22	9·525452	11 65	10·474548	9·551353	11 73	10·448647	10·025900	11 8	9·974100	38	30
36	24	9·525630	12 71	10·474370	9·551552	12 80	10·448448	10·025923	12 9	9·974077	36	24
30	26	9·525807	13 77	10·474193	9·551752	13 86	10·448248	10·025945	13 10	9·974055	34	30
37	28	9·525984	14 83	10·474016	9·551952	14 93	10·448048	10·025968	14 10	9·974032	32	23
30	30	9·526162	15 89	10·473838	9·552152	15 98	10·447848	10·025990	15 11	9·974010	30	30
38	32	9·526339	16 94	10·473661	9·552351	16 106	10·447649	10·026013	16 12	9·973987	28	22
30	34	9·526516	17 100	10·473484	9·552551	17 113	10·447449	10·026035	17 13	9·973965	26	30
39	36	9·526693	18 106	10·473307	9·552750	18 120	10·447250	10·026058	18 13	9·973942	24	21
30	38	9·526870	19 112	10·473130	9·552950	19 126	10·447050	10·026080	19 14	9·973920	22	30
40	40	9·527046	20 118	10·472954	9·553149	20 133	10·446851	10·026103	20 15	9·973897	20	20
30	42	9·527223	21 124	10·472777	9·553348	21 140	10·446652	10·026126	21 16	9·973875	18	30
41	44	9·527400	22 130	10·472600	9·553548	22 146	10·446452	10·026148	22 16	9·973852	16	19
30	46	9·527576	23 136	10·472424	9·553747	23 153	10·446253	10·026171	23 17	9·973829	14	30
42	48	9·527753	24 142	10·472247	9·553946	24 160	10·446054	10·026193	24 18	9·973807	12	18
30	50	9·527929	25 148	10·472071	9·554145	25 166	10·445855	10·026216	25 19	9·973784	10	30
43	52	9·528105	26 153	10·471895	9·554344	26 173	10·445656	10·026239	26 19	9·973761	8	17
30	54	9·528282	27 159	10·471718	9·554543	27 180	10·445457	10·026261	27 20	9·973739	6	30
44	56	9·528458	28 165	10·471542	9·554741	28 186	10·445259	10·026284	28 21	9·973716	4	16
30	58	9·528634	29 171	10·471366	9·554940	29 193	10·445060	10·026307	29 22	9·973694	2	30
46	19	9·528810	30 177	10·471190	9·555139	30 199	10·444861	10·026329	30 22	9·973671	41	15
30	2	9·528986	1 6	10·471014	9·555337	1 7	10·444663	10·026352	1 1	9·973648	58	30
46	4	9·529161	2 12	10·470839	9·555536	2 13	10·444464	10·026375	2 2	9·973625	56	14
30	6	9·529337	3 17	10·470663	9·555734	3 20	10·444266	10·026397	3 2	9·973603	54	30
47	8	9·529513	4 23	10·470487	9·555933	4 26	10·444067	10·026420	4 3	9·973580	52	13
30	10	9·529688	5 29	10·470312	9·556131	5 33	10·443869	10·026443	5 4	9·973557	50	30
48	12	9·529864	6 35	10·470136	9·556329	6 40	10·443671	10·026465	6 5	9·973535	48	12
30	14	9·530039	7 41	10·469961	9·556527	7 46	10·443473	10·026488	7 5	9·973512	46	30
49	16	9·530215	8 47	10·469785	9·556725	8 53	10·443275	10·026511	8 6	9·973489	44	11
30	18	9·530390	9 52	10·469610	9·556923	9 59	10·443077	10·026534	9 7	9·973466	42	30
50	20	9·530565	10 58	10·469435	9·557121	10 66	10·442879	10·026556	10 8	9·973444	40	10
30	22	9·530740	11 64	10·469260	9·557319	11 72	10·442681	10·026579	11 8	9·973421	38	30
51	24	9·530915	12 70	10·469085	9·557517	12 79	10·442483	10·026602	12 9	9·973398	36	9
30	26	9·531090	13 76	10·468910	9·557715	13 86	10·442285	10·026625	13 10	9·973375	34	30
52	28	9·531265	14 81	10·468735	9·557913	14 92	10·442087	10·026648	14 10	9·973352	32	8
30	30	9·531440	15 87	10·468560	9·558110	15 99	10·441890	10·026671	15 11	9·973330	30	30
53	32	9·531614	16 93	10·468386	9·558308	16 105	10·441692	10·026693	16 12	9·973307	28	7
30	34	9·531789	17 99	10·468211	9·558505	17 112	10·441495	10·026716	17 13	9·973284	26	30
54	36	9·531963	18 105	10·468037	9·558703	18 119	10·441297	10·026739	18 14	9·973261	24	6
30	38	9·532138	19 111	10·467862	9·558900	19 125	10·441100	10·026762	19 14	9·973238	22	30
55	40	9·532312	20 117	10·467688	9·559097	20 132	10·440903	10·026785	20 15	9·973215	20	5
30	42	9·532487	21 123	10·467513	9·559294	21 138	10·440706	10·026808	21 16	9·973192	18	30
56	44	9·532661	22 128	10·467339	9·559491	22 145	10·440509	10·026831	22 17	9·973169	16	4
30	46	9·532835	23 134	10·467165	9·559688	23 152	10·440312	10·026854	23 17	9·973146	14	30
57	48	9·533009	24 140	10·466991	9·559885	24 158	10·440115	10·026876	24 18	9·973124	12	3
30	50	9·533183	25 146	10·466817	9·560082	25 165	10·439918	10·026899	25 19	9·973101	10	30
58	52	9·533357	26 152	10·466643	9·560279	26 171	10·439721	10·026922	26 20	9·973078	8	2
30	54	9·533531	27 158	10·466469	9·560476	27 178	10·439524	10·026945	27 21	9·973055	6	30
59	56	9·533704	28 164	10·466296	9·560673	28 185	10·439327	10·026968	28 21	9·973032	4	1
30	58	9·533878	29 169	10·466122	9·560869	29 191	10·439131	10·026991	29 22	9·973009	2	30
60	20	9·534052	30 175	10·465948	9·561066	30 198	10·438934	10·027014	30 23	9·972986	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

70° — 4h 40m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1ʰ 20ᵐ — 20°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·534052		10·465948	9·561066		10·438934	10·027014		9·972986	40	60
30	2	9·534225	1″ 6	10·465775	9·561262	1″ 7	10·438738	10·027037	1″ 1	9·972963	58	30
1	4	9·534399	2 11	10·465601	9·561459	2 13	10·438541	10·027060	2 2	9·972940	56	59
30	6	9·534572	3 17	10·465428	9·561655	3 20	10·438345	10·027083	3 2	9·972917	54	30
2	8	9·534745	4 23	10·465255	9·561851	4 26	10·438149	10·027106	4 3	9·972894	52	58
30	10	9·534918	5 29	10·465082	9·562048	5 33	10·437952	10·027129	5 4	9·972871	50	30
3	12	9·535092	6 34	10·464908	9·562244	6 39	10·437756	10·027152	6 5	9·972848	48	57
30	14	9·535265	7 40	10·464735	9·562440	7 46	10·437560	10·027175	7 5	9·972825	46	30
4	16	9·535438	8 46	10·464562	9·562636	8 52	10·437364	10·027198	8 6	9·972802	44	56
30	18	9·535610	9 52	10·464390	9·562832	9 59	10·437168	10·027222	9 7	9·972778	42	30
5	20	9·535783	10 57	10·464217	9·563028	10 65	10·436972	10·027245	10 8	9·972755	40	55
30	22	9·535956	11 63	10·464044	9·563224	11 72	10·436776	10·027268	11 8	9·972732	38	30
6	24	9·536129	12 69	10·463871	9·563419	12 78	10·436581	10·027291	12 9	9·972709	36	54
30	26	9·536301	13 75	10·463699	9·563615	13 85	10·436385	10·027314	13 10	9·972686	34	30
7	28	9·536474	14 80	10·463526	9·563811	14 91	10·436189	10·027337	14 11	9·972663	32	53
30	30	9·536646	15 86	10·463354	9·564006	15 98	10·435994	10·027360	15 12	9·972640	30	30
8	32	9·536818	16 92	10·463182	9·564202	16 104	10·435798	10·027383	16 12	9·972617	28	52
30	34	9·536991	17 98	10·463009	9·564397	17 111	10·435603	10·027407	17 13	9·972593	26	30
9	36	9·537163	18 103	10·462837	9·564593	18 117	10·435407	10·027430	18 14	9·972570	24	51
30	38	9·537335	19 109	10·462665	9·564788	19 124	10·435212	10·027453	19 15	9·972547	22	30
10	40	9·537507	20 115	10·462493	9·564983	20 130	10·435017	10·027476	20 15	9·972524	20	50
30	42	9·537679	21 121	10·462321	9·565178	21 137	10·434822	10·027499	21 16	9·972501	18	30
11	44	9·537851	22 126	10·462149	9·565373	22 143	10·434627	10·027522	22 17	9·972478	16	49
30	46	9·538023	23 132	10·461977	9·565568	23 150	10·434432	10·027546	23 18	9·972454	14	30
12	48	9·538194	24 138	10·461806	9·565763	24 156	10·434237	10·027569	24 18	9·972431	12	48
30	50	9·538366	25 144	10·461634	9·565958	25 163	10·434042	10·027592	25 19	9·972408	10	30
13	52	9·538538	26 149	10·461462	9·566153	26 170	10·433847	10·027615	26 20	9·972385	8	47
30	54	9·538709	27 155	10·461291	9·566348	27 176	10·433652	10·027639	27 21	9·972361	6	30
14	56	9·538880	28 161	10·461120	9·566542	28 183	10·433458	10·027662	28 22	9·972338	4	46
30	58	9·539052	29 167	10·460948	9·566737	29 189	10·433263	10·027685	29 22	9·972315	2	30
15	21	9·539223	30 172	10·460777	9·566932	30 196	10·433068	10·027709	30 23	9·972291	39	45
30	2	9·539394	1 6	10·460606	9·567126	1 6	10·432874	10·027732	1 1	9·972268	58	30
16	4	9·539565	2 11	10·460435	9·567320	2 13	10·432680	10·027755	2 2	9·972245	56	44
30	6	9·539736	3 17	10·460264	9·567515	3 19	10·432485	10·027779	3 2	9·972221	54	30
17	8	9·539907	4 23	10·460093	9·567709	4 26	10·432291	10·027802	4 3	9·972198	52	43
30	10	9·540078	5 28	10·459922	9·567903	5 32	10·432097	10·027825	5 4	9·972175	50	30
18	12	9·540249	6 34	10·459751	9·568098	6 39	10·431902	10·027849	6 5	9·972151	48	42
30	14	9·540420	7 40	10·459580	9·568292	7 45	10·431708	10·027872	7 5	9·972128	46	30
19	16	9·540590	8 45	10·459410	9·568486	8 52	10·431514	10·027895	8 6	9·972105	44	41
30	18	9·540761	9 51	10·459239	9·568680	9 58	10·431320	10·027919	9 7	9·972081	42	30
20	20	9·540931	10 57	10·459069	9·568873	10 64	10·431127	10·027942	10 8	9·972058	40	40
30	22	9·541102	11 62	10·458898	9·569067	11 71	10·430933	10·027966	11 9	9·972034	38	30
21	24	9·541272	12 68	10·458728	9·569261	12 77	10·430739	10·027989	12 9	9·972011	36	39
30	26	9·541442	13 74	10·458558	9·569455	13 84	10·430545	10·028012	13 10	9·971988	34	30
22	28	9·541613	14 79	10·458387	9·569648	14 90	10·430352	10·028036	14 11	9·971964	32	38
30	30	9·541783	15 85	10·458217	9·569842	15 97	10·430158	10·028059	15 12	9·971941	30	30
23	32	9·541953	16 91	10·458047	9·570035	16 103	10·429965	10·028083	16 12	9·971917	28	37
30	34	9·542123	17 96	10·457877	9·570229	17 110	10·429771	10·028106	17 13	9·971894	26	30
24	36	9·542293	18 102	10·457707	9·570422	18 116	10·429578	10·028130	18 14	9·971870	24	36
30	38	9·542462	19 108	10·457538	9·570616	19 123	10·429384	10·028153	19 15	9·971847	22	30
25	40	9·542632	20 113	10·457368	9·570809	20 129	10·429191	10·028177	20 16	9·971823	20	35
30	42	9·542802	21 119	10·457198	9·571002	21 135	10·428998	10·028200	21 16	9·971800	18	30
26	44	9·542971	22 125	10·457029	9·571195	22 142	10·428805	10·028224	22 17	9·971776	16	34
30	46	9·543141	23 130	10·456859	9·571388	23 148	10·428612	10·028247	23 18	9·971753	14	30
27	48	9·543310	24 136	10·456690	9·571581	24 155	10·428419	10·028271	24 19	9·971729	12	33
30	50	9·543480	25 142	10·456520	9·571774	25 161	10·428226	10·028294	25 19	9·971706	10	30
28	52	9·543649	26 147	10·456351	9·571967	26 168	10·428033	10·028318	26 20	9·971682	8	32
30	54	9·543818	27 153	10·456182	9·572160	27 174	10·427840	10·028342	27 21	9·971658	6	30
29	56	9·543987	28 159	10·456013	9·572352	28 181	10·427648	10·028365	28 22	9·971635	4	31
30	58	9·544156	29 164	10·455844	9·572545	29 187	10·427455	10·028389	29 23	9·971611	2	30
30	22	9·544325	30 170	10·455675	9·572738	30 193	10·427262	10·028412	30 23	9·971588	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

69° — 4ʰ 38ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1h 22m						20°						
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·544325		10·455675	9·572738		10·427262	10·028412		9·971588	38	30
30	2	9·544494	1″ 6	10·455506	9·572930	1″ 6	10·427070	10·028436	1″ 1	9·971564	58	30
31	4	9·544663	2 11	10·455337	9·573123	2 13	10·426877	10·028460	2 2	9·971540	56	29
30	6	9·544832	3 17	10·455168	9·573315	3 19	10·426685	10·028483	3 2	9·971517	54	30
32	8	9·545000	4 22	10·455000	9·573507	4 26	10·426493	10·028507	4 3	9·971493	52	28
30	10	9·545169	5 28	10·454831	9·573700	5 32	10·426300	10·028531	5 4	9·971469	50	30
33	12	9·545338	6 34	10·454662	9·573892	6 38	10·426108	10·028554	6 5	9·971446	48	27
30	14	9·545506	7 39	10·454494	9·574084	7 45	10·425916	10·028578	7 6	9·971422	46	30
34	16	9·545674	8 45	10·454326	9·574276	8 51	10·425724	10·028602	8 6	9·971398	44	26
30	18	9·545843	9 50	10·454157	9·574468	9 58	10·425532	10·028625	9 7	9·971375	42	30
35	20	9·546011	10 56	10·453989	9·574660	10 64	10·425340	10·028649	10 8	9·971351	40	25
30	22	9·546179	11 61	10·453821	9·574852	11 70	10·425148	10·028673	11 9	9·971327	38	30
36	24	9·546347	12 67	10·453653	9·575044	12 77	10·424956	10·028697	12 9	9·971303	36	24
30	26	9·546515	13 72	10·453485	9·575236	13 83	10·424764	10·028720	13 10	9·571280	34	30
37	28	9·546683	14 78	10·453317	9·575427	14 89	10·424573	10·028744	14 11	9·971256	32	23
30	30	9·546851	15 84	10·453149	9·575619	15 96	10·424381	10·028768	15 12	9·971232	30	30
38	32	9·547019	16 90	10·452981	9·575810	16 102	10·424190	10·028792	16 13	9·971208	28	22
30	34	9·547187	17 95	10·452813	9·576002	17 109	10·423998	10·028815	17 13	9·971185	26	30
39	36	9·547354	18 101	10·452646	9·576193	18 115	10·423807	10·028839	18 14	9·971161	24	21
30	38	9·547522	19 107	10·452478	9·576385	19 121	10·423615	10·028863	19 15	9·971137	22	30
40	40	9·547689	20 112	10·452311	9·576576	20 128	10·423424	10·028887	20 16	9·971113	20	20
30	42	9·547857	21 118	10·452143	9·576767	21 134	10·423233	10·028911	21 17	9·971089	18	30
41	44	9·548024	22 123	10·451976	9·576959	22 141	10·423041	10·028934	22 17	9·971066	16	19
30	46	9·548191	23 129	10·451809	9·577150	23 147	10·422850	10·028958	23 18	9·971042	14	30
42	48	9·548359	24 134	10·451641	9·577341	24 153	10·422659	10·028982	24 19	9·971018	12	18
30	50	9·548526	25 140	10·451474	9·577532	25 160	10·422468	10·029006	25 20	9·970994	10	30
43	52	9·548693	26 145	10·451307	9·577723	26 166	10·422277	10·029030	26 21	9·970970	8	17
30	54	9·548860	27 151	10·451140	9·577914	27 173	10·422086	10·029054	27 21	9·970946	6	30
44	56	9·549027	28 156	10·450973	9·578104	28 179	10·421896	10·029078	28 22	9·970922	4	16
30	58	9·549193	29 162	10·450807	9·578295	29 185	10·421705	10·029102	29 23	9·970898	2	30
45	23	9·549360	30 168	10·450640	9·578486	30 192	10·421514	10·029126	30 24	9·970874	37	15
30	2	9·549527	1 6	10·450473	9·578676	1 6	10·421324	10·029150	1 1	9·970850	58	30
46	4	9·549693	2 11	10·450307	9·578867	2 13	10·421133	10·029173	2 2	9·970827	56	14
30	6	9·549860	3 17	10·450140	9·579057	3 19	10·420943	10·029197	3 2	9·970803	54	30
47	8	9·550026	4 22	10·449974	9·579248	4 25	10·420752	10·029221	4 3	9·970779	52	13
30	10	9·550193	5 28	10·449807	9·579438	5 32	10·420562	10·029245	5 4	9·970755	50	30
48	12	9·550359	6 33	10·449641	9·579629	6 38	10·420371	10·029269	6 5	9·970731	48	12
30	14	9·550525	7 39	10·449475	9·579819	7 44	10·420181	10·029293	7 6	9·970707	46	30
49	16	9·550692	8 44	10·449308	9·580009	8 51	10·419991	10·029317	8 6	9·970683	44	11
30	18	9·550858	9 50	10·449142	9·580199	9 57	10·419801	10·029341	9 7	9·970659	42	30
50	20	9·551024	10 55	10·448976	9·580389	10 63	10·419611	10·029365	10 8	9·970635	40	10
30	22	9·551190	11 61	10·448810	9·580579	11 70	10·419421	10·029389	11 9	9·970611	38	30
51	24	9·551356	12 66	10·448644	9·580769	12 76	10·419231	10·029414	12 10	9·970586	36	9
30	26	9·551521	13 72	10·448479	9·580959	13 82	10·419041	10·029438	13 10	9·970562	34	30
52	28	9·551687	14 77	10·448313	9·581149	14 88	10·418851	10·029462	14 11	9·970538	32	8
30	30	9·551853	15 83	10·448147	9·581339	15 95	10·418661	10·029486	15 12	9·970514	30	30
53	22	9·552018	16 88	10·447982	9·581528	16 101	10·418472	10·029510	16 13	9·970490	28	7
30	34	9·552184	17 94	10·447816	9·581718	17 107	10·418282	10·029534	17 14	9·970466	26	30
54	36	9·552349	18 99	10·447651	9·581907	18 114	10·418093	10·029558	18 14	9·970442	24	6
30	38	9·552515	19 105	10·447485	9·582097	19 120	10·417903	10·029582	19 15	9·970418	22	30
55	40	9·552680	20 110	10·447320	9·582286	20 126	10·417714	10·029606	20 16	9·970394	20	5
30	42	9·552845	21 116	10·447155	9·582476	21 133	10·417524	10·029630	21 17	9·970370	18	30
56	44	9·553010	22 121	10·446990	9·582665	22 139	10·417335	10·029655	22 18	9·970345	16	4
30	46	9·553176	23 127	10·446824	9·582854	23 145	10·417146	10·029679	23 18	9·970321	14	30
57	48	9·553341	24 132	10·446659	9·583044	24 152	10·416956	10·029703	24 19	9·970297	12	3
30	50	9·553506	25 138	10·446494	9·583233	25 158	10·416767	10·029727	25 20	9·970273	10	30
58	52	9·553670	26 143	10·446330	9·583422	26 164	10·416578	10·029751	26 21	9·970249	8	2
30	54	9·553835	27 149	10·446165	9·583611	27 171	10·416389	10·029776	27 22	9·970224	6	30
59	56	9·554000	28 154	10·446000	9·583800	28 177	10·416200	10·029800	28 22	9·970200	4	1
30	58	9·554165	29 160	10·445835	9·583989	29 183	10·416011	10·029824	29 23	9·970176	2	30
60	24	9·554329	30 166	10·445671	9·584177	30 190	10·415823	10·029848	30 24	9·970152	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
						69°					4h 36m	

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1ʰ 24ᵐ — 21°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·554329		10·445671	9·584177		10·415823	10·029848		9·970152	**36**	60
30	2	9·554494	1″ 5	10·445506	9·584366	1″ 6	10·415634	10·029873	1″ 1	9·970127	58	30
1	4	9·554658	2 11	10·445342	9·584555	2 13	10·415445	10·029897	2 2	9·970103	56	59
30	6	9·554822	3 16	10·445178	9·584744	3 19	10·415256	10·029921	3 2	9·970079	54	30
2	8	9·554987	4 22	10·445013	9·584932	4 25	10·415068	10·029945	4 3	9·970055	52	58
30	10	9·555151	5 27	10·444849	9·585121	5 31	10·414879	10·029970	5 4	9·970030	50	30
3	12	9·555315	6 33	10·444685	9·585309	6 38	10·414691	10·029994	6 5	9·970006	48	57
30	14	9·555479	7 38	10·444521	9·585498	7 44	10·414502	10·030018	7 6	9·969982	46	30
4	16	9·555643	8 44	10·444357	9·585686	8 50	10·414314	10·030043	8 7	9·969957	44	56
30	18	9·555807	9 49	10·444193	9·585874	9 56	10·414126	10·030067	9 7	9·969933	42	30
5	20	9·555971	10 54	10·444029	9·586062	10 63	10·413938	10·030091	10 8	9·969909	40	55
30	22	9·556135	11 60	10·443865	9·586251	11 69	10·413749	10·030116	11 9	9·969884	38	30
6	24	9·556299	12 65	10·443701	9·586439	12 75	10·413561	10·030140	12 10	9·969860	36	54
30	26	9·556462	13 71	10·443538	9·586627	13 81	10·413373	10·030164	13 11	9·969836	34	30
7	28	9·556626	14 76	10·443374	9·586815	14 88	10·413185	10·030189	14 11	9·969811	32	53
30	30	9·556789	15 82	10·443211	9·587003	15 94	10·412997	10·030213	15 12	9·969787	30	30
8	32	9·556953	16 87	10·443047	9·587190	16 100	10·412810	10·030238	16 13	9·969762	28	52
30	34	9·557116	17 93	10·442884	9·587378	17 106	10·412622	10·030262	17 14	9·969738	26	30
9	36	9·557280	18 98	10·442720	9·587566	18 113	10·412434	10·030286	18 15	9·969714	24	51
30	38	9·557443	19 104	10·442557	9·587754	19 119	10·412246	10·030311	19 15	9·969689	22	30
10	40	9·557606	20 109	10·442394	9·587941	20 125	10·412059	10·030335	20 16	9·969665	20	50
30	42	9·557769	21 115	10·442231	9·588129	21 131	10·411871	10·030360	21 17	9·969640	18	30
11	44	9·557932	22 120	10·442068	9·588316	22 138	10·411684	10·030384	22 18	9·969616	16	49
30	46	9·558095	23 126	10·441905	9·588504	23 144	10·411496	10·030409	23 19	9·969591	14	30
12	48	9·558258	24 131	10·441742	9·588691	24 150	10·411309	10·030433	24 19	9·969567	12	48
30	50	9·558421	25 137	10·441579	9·588878	25 156	10·411122	10·030458	25 20	9·969542	10	30
13	52	9·558583	26 142	10·441417	9·589066	26 163	10·410934	10·030482	26 21	9·969518	8	47
30	54	9·558746	27 147	10·441254	9·589253	27 169	10·410747	10·030507	27 22	9·969493	6	30
14	56	9·558909	28 153	10·441091	9·589440	28 175	10·410560	10·030531	28 23	9·969469	4	46
30	58	9·559071	29 158	10·440929	9·589627	29 182	10·410373	10·030556	29 23	9·969444	2	30
15	**25**	9·559234	30 163	10·440766	9·589814	30 188	10·410186	10·030580	30 24	9·969420	**35**	45
30	2	9·559396	1 5	10·440604	9·590001	1 6	10·409999	10·030605	1 1	9·969395	58	30
16	4	9·559558	2 11	10·440442	9·590188	2 12	10·409812	10·030630	2 2	9·969370	56	44
30	6	9·559721	3 16	10·440279	9·590375	3 19	10·409625	10·030654	3 2	9·969346	54	30
17	8	9·559883	4 22	10·440117	9·590562	4 25	10·409438	10·030679	4 3	9·969321	52	43
30	10	9·560045	5 27	10·439955	9·590748	5 31	10·409252	10·030703	5 4	9·969297	50	30
18	12	9·560207	6 32	10·439793	9·590935	6 37	10·409065	10·030728	6 5	9·969272	48	42
30	14	9·560369	7 38	10·439631	9·591122	7 43	10·408878	10·030753	7 6	9·969247	46	30
19	16	9·560531	8 43	10·439469	9·591308	8 50	10·408692	10·030777	8 7	9·969223	44	41
30	18	9·560693	9 48	10·439307	9·591495	9 56	10·408505	10·030802	9 7	9·969198	42	30
20	20	9·560855	10 54	10·439145	9·591681	10 61	10·408319	10·030827	10 8	9·969173	40	40
30	22	9·561016	11 59	10·438984	9·591867	11 68	10·408132	10·030851	11 9	9·969149	38	30
21	24	9·561178	12 65	10·438822	9·592054	12 74	10·407946	10·030876	12 10	9·969124	36	39
30	26	9·561339	13 70	10·438661	9·592240	13 81	10·407760	10·030901	13 11	9·969099	34	30
22	28	9·561501	14 75	10·438499	9·592426	14 87	10·407574	10·030925	14 11	9·969075	32	38
30	30	9·561662	15 81	10·438338	9·592612	15 93	10·407388	10·030950	15 12	9·969050	30	30
23	32	9·561824	16 86	10·438176	9·592799	16 99	10·407201	10·030975	16 13	9·969025	28	37
30	34	9·561985	17 91	10·438015	9·592985	17 105	10·407015	10·031000	17 14	9·969000	26	30
24	36	9·562146	18 97	10·437854	9·593171	18 112	10·406829	10·031024	18 15	9·968976	24	36
30	38	9·562307	19 102	10·437693	9·593356	19 118	10·406644	10·031049	19 16	9·968951	22	30
25	40	9·562468	20 108	10·437532	9·593542	20 124	10·406458	10·031074	20 16	9·968926	20	35
30	42	9·562629	21 113	10·437371	9·593728	21 130	10·406272	10·031099	21 17	9·968901	18	30
26	44	9·562790	22 119	10·437210	9·593914	22 136	10·406086	10·031123	22 18	9·968877	16	34
30	46	9·562951	23 124	10·437049	9·594099	23 143	10·405901	10·031148	23 19	9·968852	14	30
27	48	9·563112	24 129	10·436888	9·594285	24 149	10·405715	10·031173	24 20	9·968827	12	33
30	50	9·563273	25 135	10·436727	9·594471	25 155	10·405529	10·031198	25 20	9·968802	10	30
28	52	9·563433	26 140	10·436567	9·594656	26 161	10·405344	10·031223	26 21	9·968777	8	32
30	54	9·563594	27 145	10·436406	9·594842	27 167	10·405158	10·031248	27 22	9·968752	6	30
29	56	9·563755	28 151	10·436245	9·595027	28 174	10·404973	10·031272	28 23	9·968728	4	31
30	58	9·563915	29 156	10·436085	9·595212	29 180	10·404788	10·031297	29 24	9·968703	2	30
30	**26**	9·564075	30 161	10·435925	9·595398	30 186	10·404602	10·031322	30 25	9·968678	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

68° — 4ʰ 34ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1h 26m — 21°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·564075		10·435925	9·595398		10·404602	10·031322		9·968678	34	30
30	2	9·564236	1″ 5	10·435764	9·595583	1″ 6	10·404417	10·031347	1″ 1	9·968653	58	30
31	4	9·564396	2 11	10·435604	9·595768	2 12	10·404232	10·031372	2 2	9·968628	56	29
30	6	9·564556	3 16	10·435444	9·595953	3 18	10·404047	10·031397	3 3	9·968603	54	30
32	8	9·564716	4 21	10·435284	9·596138	4 25	10·403862	10·031422	4 3	9·968578	52	28
30	10	9·564876	5 27	10·435124	9·596323	5 31	10·403677	10·031447	5 4	9·968553	50	30
33	12	9·565036	6 32	10·434964	9·596508	6 37	10·403492	10·031472	6 5	9·968528	48	27
30	14	9·565196	7 37	10·434804	9·596693	7 43	10·403307	10·031497	7 6	9·968503	46	30
34	16	9·565356	8 42	10·434644	9·596878	8 49	10·403122	10·031521	8 7	9·968479	44	26
30	18	9·565516	9 48	10·434484	9·597062	9 55	10·402938	10·031546	9 8	9·968454	42	30
35	20	9·565676	10 53	10·434324	9·597247	10 61	10·402753	10·031571	10 8	9·968429	40	25
30	22	9·565835	11 58	10·434165	9·597432	11 68	10·402568	10·031596	11 9	9·968404	38	30
36	24	9·565995	12 64	10·434005	9·597616	12 74	10·402384	10·031621	12 10	9·968379	36	24
30	26	9·566154	13 69	10·433846	9·597801	13 80	10·402199	10·031646	13 11	9·968354	34	30
37	28	9·566314	14 74	10·433686	9·597985	14 86	10·402015	10·031671	14 12	9·968329	32	23
30	30	9·566473	15 80	10·433527	9·598170	15 92	10·401830	10·031697	15 12	9·968303	30	30
38	32	9·566632	16 85	10·433368	9·598354	16 98	10·401646	10·031722	16 13	9·968278	28	22
30	34	9·566792	17 90	10·433208	9·598538	17 105	10·401462	10·031747	17 14	9·968253	26	30
39	36	9·566951	18 96	10·433049	9·598722	18 111	10·401278	10·031772	18 15	9·968228	24	21
30	38	9·567110	19 101	10·432890	9·598907	19 117	10·401093	10·031797	19 16	9·968203	22	30
40	40	9·567269	20 106	10·432731	9·599091	20 123	10·400909	10·031822	20 17	9·968178	20	20
30	42	9·567428	21 112	10·432572	9·599275	21 129	10·400725	10·031847	21 17	9·968153	18	30
41	44	9·567587	22 117	10·432413	9·599459	22 135	10·400541	10·031872	22 18	9·968128	16	19
30	46	9·567746	23 122	10·432254	9·599643	23 141	10·400357	10·031897	23 19	9·968103	14	30
42	48	9·567904	24 127	10·432096	9·599827	24 148	10·400173	10·031922	24 20	9·968078	12	18
30	50	9·568063	25 133	10·431937	9·600011	25 154	10·399989	10·031947	25 21	9·968053	10	30
43	52	9·568222	26 138	10·431778	9·600194	26 160	10·399806	10·031973	26 22	9·968027	8	17
30	54	9·568380	27 143	10·431620	9·600378	27 166	10·399622	10·031998	27 22	9·968002	6	30
44	56	9·568539	28 149	10·431461	9·600562	28 172	10·399438	10·032023	28 23	9·967977	4	16
30	58	9·568697	29 154	10·431303	9·600745	29 178	10·399255	10·032048	29 24	9·967952	2	30
45	27	9·568856	30 159	10·431144	9·600929	30 184	10·399071	10·032073	30 25	9·967927	33	15
30	2	9·569014	1 5	10·430986	9·601112	1 6	10·398888	10·032099	1 1	9·967901	58	30
46	4	9·569172	2 10	10·430828	9·601296	2 12	10·398704	10·032124	2 2	9·967876	56	14
30	6	9·569330	3 16	10·430670	9·601479	3 18	10·398521	10·032149	3 3	9·967851	54	30
47	8	9·569488	4 21	10·430512	9·601663	4 24	10·398337	10·032174	4 3	9·967826	52	13
30	10	9·569646	5 26	10·430354	9·601846	5 30	10·398154	10·032199	5 4	9·967801	50	30
48	12	9·569804	6 31	10·430196	9·602029	6 37	10·397971	10·032225	6 5	9·967775	48	12
30	14	9·569962	7 37	10·430038	9·602212	7 43	10·397788	10·032250	7 6	9·967750	46	30
49	16	9·570120	8 42	10·429880	9·602395	8 49	10·397605	10·032275	8 7	9·967725	44	11
30	18	9·570278	9 47	10·429722	9·602578	9 55	10·397422	10·032301	9 8	9·967699	42	30
50	20	9·570435	10 52	10·429565	9·602761	10 61	10·397239	10·032326	10 8	9·967674	40	10
30	22	9·570593	11 58	10·429407	9·602944	11 67	10·397056	10·032351	11 9	9·967649	38	30
51	24	9·570751	12 63	10·429249	9·603127	12 73	10·396873	10·032376	12 10	9·967624	36	9
30	26	9·570908	13 68	10·429092	9·603310	13 79	10·396690	10·032402	13 11	9·967598	34	30
52	28	9·571066	14 73	10·428934	9·603493	14 85	10·396507	10·032427	14 12	9·967573	32	8
30	30	9·571223	15 79	10·428777	9·603675	15 91	10·396325	10·032453	15 13	9·967547	30	30
53	32	9·571380	16 84	10·428620	9·603858	16 97	10·396142	10·032478	16 14	9·967522	28	7
30	34	9·571537	17 89	10·428463	9·604041	17 104	10·395959	10·032503	17 14	9·967497	26	30
54	36	9·571695	18 95	10·428305	9·604223	18 110	10·395777	10·032529	18 15	9·967471	24	6
30	38	9·571852	19 100	10·428148	9·604406	19 116	10·395594	10·032554	19 16	9·967446	22	30
55	40	9·572009	20 105	10·427991	9·604588	20 122	10·395412	10·032579	20 17	9·967421	20	5
30	42	9·572166	21 110	10·427834	9·604771	21 128	10·395229	10·032605	21 18	9·967395	18	30
56	44	9·572323	22 116	10·427677	9·604953	22 134	10·395047	10·032630	22 19	9·967370	16	4
30	46	9·572479	23 121	10·427521	9·605135	23 140	10·394865	10·032656	23 20	9·967344	14	30
57	48	9·572636	24 126	10·427364	9·605317	24 146	10·394683	10·032681	24 20	9·967319	12	3
30	50	9·572793	25 131	10·427207	9·605500	25 152	10·394500	10·032707	25 21	9·967293	10	30
58	52	9·572950	26 137	10·427050	9·605682	26 158	10·394318	10·032732	26 22	9·967268	8	2
30	54	9·573106	27 142	10·426894	9·605864	27 164	10·394136	10·032758	27 23	9·967242	6	30
59	56	9·573263	28 147	10·426737	9·606046	28 171	10·393954	10·032783	28 24	9·967217	4	1
30	58	9·573419	29 152	10·426581	9·606228	29 177	10·393772	10·032809	29 25	9·967191	2	30
60	28	9·573575	30 157	10·426425	9·606410	30 183	10·393590	10·032834	30 25	9·967166	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

68° — 4h 32m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1h 28m — 22°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·573575		10·426415	9·606410		10·393590	10·032834		9·967166	32	60
30	2	9·573732	1″ 5	10·426268	9·606591	1″ 6	10·393409	10·032860	1″ 1	9·967140	58	30
1	4	9·573888	2 10	10·426112	9·606773	2 12	10·393227	10·032885	2 2	9·967115	56	59
30	6	9·574044	3 16	10·425956	9·606955	3 18	10·393045	10·032911	3 3	9·967089	54	30
2	8	9·574200	4 21	10·425800	9·607137	4 24	10·392863	10·032936	4 3	9·967064	52	58
30	10	9·574356	5 26	10·425644	9·607318	5 30	10·392682	10·032962	5 4	9·967038	50	30
3	12	9·574512	6 31	10·425488	9·607500	6 36	10·392500	10·032987	6 5	9·967013	48	57
30	14	9·574668	7 36	10·425332	9·607681	7 42	10·392319	10·033013	7 6	9·966987	46	30
4	16	9·574824	8 41	10·425176	9·607863	8 48	10·392137	10·033039	8 7	9·966961	44	56
30	18	9·574980	9 47	10·425020	9·608044	9 54	10·391956	10·033064	9 8	9·966936	42	30
5	20	9·575136	10 52	10·424864	9·608225	10 60	10·391775	10·033090	10 9	9·966910	40	55
30	22	9·575291	11 57	10·424709	9·608407	11 66	10·391593	10·033116	11 9	9·966884	38	30
6	24	9·575447	12 62	10·424553	9·608588	12 72	10·391412	10·033141	12 10	9·966859	36	54
30	26	9·575602	13 67	10·424398	9·608769	13 78	10·391231	10·033167	13 11	9·966833	34	30
7	28	9·575758	14 73	10·424242	9·608950	14 84	10·391050	10·033192	14 12	9·966808	32	53
30	30	9·575913	15 78	10·424087	9·609131	15 90	10·390869	10·033218	15 13	9·966782	30	30
8	32	9·576069	16 83	10·423931	9·609312	16 96	10·390688	10·033244	16 14	9·966756	28	52
30	34	9·576224	17 88	10·423776	9·609493	17 103	10·390507	10·033270	17 14	9·966730	26	30
9	36	9·576379	18 93	10·423621	9·609674	18 109	10·390326	10·033295	18 15	9·966705	24	51
30	38	9·576534	19 99	10·423466	9·609855	19 115	10·390145	10·033321	19 16	9·966679	22	30
10	40	9·576689	20 104	10·423311	9·610036	20 121	10·389964	10·033347	20 17	9·966653	20	50
30	42	9·576844	21 109	10·423156	9·610217	21 127	10·389783	10·033372	21 18	9·966628	18	30
11	44	9·576999	22 114	10·423001	9·610397	22 133	10·389603	10·033398	22 19	9·966602	16	49
30	46	9·577154	23 119	10·422846	9·610578	23 139	10·389422	10·033424	23 20	9·966576	14	30
12	48	9·577309	24 124	10·422691	9·610759	24 145	10·389241	10·033450	24 21	9·966550	12	48
30	50	9·577464	25 130	10·422536	9·610939	25 151	10·389061	10·033475	25 21	9·966525	10	30
13	52	9·577618	26 135	10·422382	9·611120	26 157	10·388880	10·033501	26 22	9·966499	8	47
30	54	9·577773	27 140	10·422227	9·611300	27 163	10·388700	10·033527	27 23	9·966473	6	30
14	56	9·577927	28 145	10·422073	9·611480	28 169	10·388520	10·033553	28 24	9·966447	4	46
30	58	9·578082	29 150	10·421918	9·611661	29 175	10·388339	10·033579	29 25	9·966421	2	30
15	**29**	9·578236	30 155	10·421764	9·611841	30 181	10·388159	10·033605	30 26	9·966395	**31**	45
30	2	9·578391	1 5	10·421609	9·612021	1 6	10·387979	10·033630	1 1	9·966370	58	30
16	4	9·578545	2 10	10·421455	9·612201	2 12	10·387799	10·033656	2 2	9·966344	56	44
30	6	9·578699	3 15	10·421301	9·612381	3 18	10·387619	10·033682	3 3	9·966318	54	30
17	8	9·578853	4 20	10·421147	9·612561	4 24	10·387439	10·033708	4 3	9·966292	52	43
30	10	9·579008	5 26	10·420992	9·612741	5 30	10·387259	10·033734	5 4	9·966266	50	30
18	12	9·579162	6 31	10·420838	9·612921	6 36	10·387079	10·033760	6 5	9·966240	48	42
30	14	9·579316	7 36	10·420684	9·613101	7 42	10·386899	10·033786	7 6	9·966214	46	30
19	16	9·579470	8 41	10·420530	9·613281	8 48	10·386719	10·033812	8 7	9·966188	44	41
30	18	9·579623	9 46	10·420377	9·613461	9 54	10·386539	10·033838	9 8	9·966162	42	30
20	20	9·579777	10 51	10·420223	9·613641	10 60	10·386359	10·033864	10 9	9·966136	40	40
30	22	9·579931	11 56	10·420069	9·613820	11 66	10·386180	10·033890	11 10	9·966110	38	30
21	24	9·580085	12 61	10·419915	9·614000	12 72	10·386000	10·033915	12 10	9·966085	36	39
30	26	9·580238	13 66	10·419762	9·614180	13 78	10·385820	10·033941	13 11	9·966059	34	30
22	28	9·580392	14 71	10·419608	9·614359	14 84	10·385641	10·033967	14 12	9·966033	32	38
30	30	9·580545	15 77	10·419455	9·614539	15 90	10·385461	10·033993	15 13	9·966007	30	30
23	32	9·580699	16 82	10·419301	9·614718	16 96	10·385282	10·034019	16 14	9·965981	28	37
30	34	9·580852	17 87	10·419148	9·614897	17 102	10·385103	10·034045	17 15	9·965955	26	30
24	36	9·581005	18 92	10·418995	9·615077	18 108	10·384923	10·034071	18 16	9·965929	24	36
30	38	9·581158	19 97	10·418842	9·615256	19 114	10·384744	10·034098	19 17	9·965902	22	30
25	40	9·581312	20 102	10·418688	9·615435	20 120	10·384565	10·034124	20 17	9·965876	20	35
30	42	9·581465	21 107	10·418535	9·615614	21 126	10·384386	10·034150	21 18	9·965850	18	30
26	44	9·581618	22 112	10·418382	9·615793	22 132	10·384207	10·034176	22 19	9·965824	16	34
30	46	9·581771	23 118	10·418229	9·615972	23 138	10·384028	10·034202	23 20	9·965798	14	30
27	48	9·581924	24 123	10·418076	9·616151	24 144	10·383849	10·034228	24 21	9·965772	12	33
30	50	9·582076	25 128	10·417924	9·616330	25 149	10·383670	10·034254	25 22	9·965746	10	30
28	52	9·582229	26 133	10·417771	9·616509	26 155	10·383491	10·034280	26 23	9·965720	8	32
30	54	9·582382	27 138	10·417618	9·616688	27 161	10·383312	10·034306	27 23	9·965694	6	30
29	56	9·582535	28 143	10·417465	9·616867	28 167	10·383133	10·034332	28 24	9·965668	4	31
30	58	9·582687	29 148	10·417313	9·617046	29 173	10·382954	10·034358	29 25	9·965642	2	30
30	**30**	9·582840	30 153	10·417160	9·617224	30 179	10·382776	10·034385	30 26	9·965615	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m.	′ ″

67° — 4h 30m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

$1^h\ 30^m$ — 22°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·582840		10·417160	9·617224		10·382776	10·034385		9·965615	60	30
30	2	9·582992	1″ 5	10·417008	9·617403	1″ 6	10·382597	10·034411	1″ 1	9·965589	58	30
31	4	9·583145	2 10	10·416855	9·617582	2 12	10·382418	10·034437	2 2	9·965563	56	29
30	6	9·583297	3 15	10·416703	9·617760	3 18	10·382240	10·034463	3 3	9·965537	54	30
32	8	9·583449	4 20	10·416551	9·617939	4 24	10·382061	10·034489	4 4	9·965511	52	28
30	10	9·583601	5 25	10·416399	9·618117	5 30	10·381883	10·034516	5 4	9·965484	50	30
33	12	9·583754	6 30	10·416246	9·618295	6 36	10·381705	10·034542	6 5	9·965458	48	27
30	14	9·583906	7 35	10·416094	9·618474	7 42	10·381526	10·034568	7 6	9·965432	46	30
34	16	9·584058	8 40	10·415942	9·618652	8 47	10·381348	10·034594	8 7	9·965406	44	26
30	18	9·584210	9 45	10·415790	9·618830	9 53	10·381170	10·034621	9 8	9·965379	42	30
35	20	9·584361	10 50	10·415639	9·619008	10 59	10·380992	10·034647	10 9	9·965353	40	25
30	22	9·584513	11 56	10·415487	9·619186	11 65	10·380814	10·034673	11 10	9·965327	38	30
36	24	9·584665	12 61	10·415335	9·619364	12 71	10·380636	10·034699	12 11	9·965301	36	24
30	26	9·584817	13 66	10·415183	9·619543	13 77	10·380457	10·034726	13 11	9·965274	34	30
37	28	9·584968	14 71	10·415032	9·619720	14 83	10·380280	10·034752	14 12	9·965248	32	23
30	30	9·585120	15 76	10·414880	9·619898	15 90	10·380102	10·034778	15 13	9·965222	30	30
38	32	9·585272	16 81	10·414728	9·620076	16 95	10·379924	10·034805	16 14	9·965195	28	22
30	34	9·585423	17 86	10·414577	9·620254	17 101	10·379746	10·034831	17 15	9·965169	26	30
39	36	9·585574	18 91	10·414426	9·620432	18 107	10·379568	10·034857	18 16	9·965143	24	21
30	38	9·585726	19 96	10·414274	9·620610	19 113	10·379390	10·034884	19 17	9·965116	22	30
40	40	9·585877	20 101	10·414123	9·620787	20 119	10·379213	10·034910	20 18	9·965090	20	20
30	42	9·586028	21 106	10·413972	9·620965	21 125	10·379035	10·034936	21 18	9·965064	18	30
41	44	9·586179	22 111	10·413821	9·621142	22 130	10·378858	10·034963	22 19	9·965037	16	19
30	46	9·586331	23 116	10·413669	9·621320	23 136	10·378680	10·034989	23 20	9·965011	14	30
42	48	9·586482	24 121	10·413518	9·621497	24 142	10·378503	10·035016	24 21	9·964984	12	18
30	50	9·586633	25 126	10·413367	9·621675	25 148	10·378325	10·035042	25 22	9·964958	10	30
43	52	9·586783	26 131	10·413217	9·621852	26 154	10·378148	10·035069	26 23	9·964931	8	17
30	54	9·586934	27 136	10·413066	9·622029	27 160	10·377971	10·035095	27 24	9·964905	6	30
44	56	9·587085	28 141	10·412915	9·622207	28 166	10·377793	10·035121	28 25	9·964879	4	16
30	58	9·587236	29 146	10·412764	9·622384	29 172	10·377616	10·035148	29 26	9·964852	2	30
45	60	9·587386	30 151	10·412614	9·622561	30 178	10·377439	10·035174	30 26	9·964826	0	15
30	2	9·587537	1 5	10·412463	9·622738	1 6	10·377262	10·035201	1 1	9·964799	58	30
46	4	9·587688	2 10	10·412312	9·622915	2 12	10·377085	10·035227	2 2	9·964773	56	14
30	6	9·587838	3 15	10·412162	9·623092	3 18	10·376908	10·035254	3 3	9·964746	54	30
47	8	9·587989	4 20	10·412011	9·623269	4 24	10·376731	10·035280	4 4	9·964720	52	13
30	10	9·588139	5 25	10·411861	9·623446	5 29	10·376554	10·035307	5 4	9·964693	50	30
48	12	9·588289	6 30	10·411711	9·623623	6 35	10·376377	10·035334	6 5	9·964666	48	12
30	14	9·588439	7 35	10·411561	9·623800	7 41	10·376200	10·035360	7 6	9·964640	46	30
49	16	9·588590	8 40	10·411410	9·623976	8 47	10·376024	10·035387	8 7	9·964613	44	11
30	18	9·588740	9 45	10·411260	9·624153	9 53	10·375847	10·035413	9 8	9·964587	42	30
50	20	9·588890	10 50	10·411110	9·624330	10 59	10·375670	10·035440	10 9	9·964560	40	10
30	22	9·589040	11 55	10·410960	9·624506	11 65	10·375494	10·035466	11 10	9·964534	38	30
51	24	9·589190	12 60	10·410810	9·624683	12 71	10·375317	10·035493	12 11	9·964507	36	9
30	26	9·589340	13 65	10·410660	9·624859	13 76	10·375141	10·035520	13 12	9·964480	34	30
52	28	9·589489	14 70	10·410511	9·625036	14 82	10·374964	10·035546	14 12	9·964454	32	8
30	30	9·589639	15 75	10·410361	9·625212	15 88	10·374788	10·035573	15 13	9·964427	30	30
53	32	9·589789	16 80	10·410211	9·625388	16 94	10·374612	10·035600	16 14	9·964400	28	7
30	34	9·589938	17 85	10·410062	9·625565	17 100	10·374435	10·035626	17 15	9·964374	26	30
54	36	9·590088	18 90	10·409912	9·625741	18 106	10·374259	10·035653	18 16	9·964347	24	6
30	38	9·590237	19 95	10·409763	9·625917	19 112	10·374083	10·035680	19 17	9·964320	22	30
55	40	9·590387	20 100	10·409613	9·626093	20 118	10·373907	10·035706	20 18	9·964294	20	5
30	42	9·590536	21 105	10·409464	9·626269	21 123	10·373731	10·035733	21 19	9·964267	18	30
56	44	9·590686	22 110	10·409314	9·626445	22 129	10·373555	10·035760	22 20	9·964240	16	4
30	46	9·590835	23 115	10·409165	9·626621	23 135	10·373379	10·035786	23 20	9·964214	14	30
57	48	9·590984	24 120	10·409016	9·626797	24 141	10·373203	10·035813	24 21	9·964187	12	3
30	50	9·591133	25 125	10·408867	9·626973	25 147	10·373027	10·035840	25 22	9·964160	10	30
58	52	9·591282	26 130	10·408718	9·627149	26 153	10·372851	10·035867	26 23	9·964133	8	2
30	54	9·591431	27 135	10·408569	9·627325	27 159	10·372675	10·035894	27 24	9·964106	6	30
59	56	9·591580	28 140	10·408420	9·627501	28 165	10·372499	10·035920	28 25	9·964080	4	1
30	58	9·591729	29 145	10·408271	9·627676	29 171	10·372324	10·035947	29 26	9·964053	2	30
60	60	9·591878	30 150	10·408122	9·627852	30 176	10·372148	10·035974	30 27	9·964026	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

67° — $4^h\ 28^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1h 32m — 23°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·591878		10·408122	9·627851		10·372148	10·035974		9·964026	28	60
30	2	9·592027	1″ 5	10·407973	9·628028	1″ 6	10·371972	10·036001	1″ 1	9·963999	58	30
1	4	9·592176	2 10	10·407824	9·628203	2 12	10·371797	10·036028	2 2	9·963972	56	59
30	6	9·592324	3 15	10·407676	9·628379	3 17	10·371621	10·036054	3 3	9·963946	54	30
2	8	9·592473	4 20	10·407527	9·628554	4 23	10·371446	10·036081	4 4	9·963919	52	58
30	10	9·592621	5 25	10·407379	9·628729	5 29	10·371271	10·036108	5 4	9·963892	50	30
3	12	9·592770	6 30	10·407230	9·628905	6 35	10·371095	10·036135	6 5	9·963865	48	57
30	14	9·592918	7 35	10·407082	9·629080	7 41	10·370920	10·036162	7 6	9·963838	46	30
4	16	9·593067	8 39	10·406933	9·629255	8 47	10·370745	10·036189	8 7	9·963811	44	56
30	18	9·593215	9 44	10·406785	9·629431	9 52	10·370569	10·036216	9 8	9·963784	42	30
5	20	9·593363	10 49	10·406637	9·629606	10 58	10·370394	10·036243	10 9	9·963757	40	55
30	22	9·593511	11 54	10·406489	9·629781	11 64	10·370219	10·036270	11 10	9·963730	38	30
6	24	9·593659	12 59	10·406341	9·629956	12 70	10·370044	10·036296	12 11	9·963704	36	54
30	26	9·593807	13 64	10·406193	9·630131	13 76	10·369869	10·036323	13 12	9·963677	34	30
7	28	9·593955	14 69	10·406045	9·630306	14 82	10·369694	10·036350	14 13	9·963650	32	53
30	30	9·594103	15 74	10·405897	9·630481	15 87	10·369519	10·036377	15 13	9·963623	30	30
8	32	9·594251	16 79	10·405749	9·630656	16 93	10·369344	10·036404	16 14	9·963596	28	52
30	34	9·594399	17 84	10·405601	9·630830	17 99	10·369170	10·036431	17 15	9·963569	26	30
9	36	9·594547	18 89	10·405453	9·631005	18 105	10·368995	10·036458	18 16	9·963542	24	51
30	38	9·594695	19 94	10·405305	9·631180	19 111	10·368820	10·036485	19 17	9·963515	22	30
10	40	9·594842	20 99	10·405158	9·631355	20 117	10·368645	10·036512	20 18	9·963488	20	50
30	42	9·594990	21 104	10·405010	9·631529	21 122	10·368471	10·036539	21 19	9·963461	18	30
11	44	9·595137	22 109	10·404863	9·631704	22 128	10·368296	10·036566	22 20	9·963434	16	49
30	46	9·595285	23 114	10·404715	9·631878	23 134	10·368122	10·036593	23 21	9·963407	14	30
12	48	9·595432	24 118	10·404568	9·632053	24 140	10·367947	10·036621	24 22	9·963379	12	48
30	50	9·595580	25 123	10·404420	9·632227	25 146	10·367773	10·036648	25 22	9·963352	10	30
13	52	9·595727	26 128	10·404273	9·632402	26 152	10·367598	10·036675	26 23	9·963325	8	47
30	54	9·595874	27 133	10·404126	9·632576	27 157	10·367424	10·036702	27 24	9·963298	6	30
14	56	9·596021	28 138	10·403979	9·632750	28 163	10·367250	10·036729	28 25	9·963271	4	46
30	58	9·596168	29 143	10·403832	9·632924	29 169	10·367076	10·036756	29 26	9·963244	2	30
15	33	9·596315	30 148	10·403685	9·633099	30 175	10·366901	10·036783	30 27	9·963217	27	45
30	2	9·596462	1 5	10·403538	9·633273	1 6	10·366727	10·036810	1 1	9·963190	58	30
16	4	9·596609	2 10	10·403391	9·633447	2 12	10·366553	10·036837	2 2	9·963163	56	44
30	6	9·596756	3 15	10·403244	9·633621	3 17	10·366379	10·036865	3 3	9·963135	54	30
17	8	9·596903	4 20	10·403097	9·633795	4 23	10·366205	10·036892	4 4	9·963108	52	43
30	10	9·597050	5 24	10·402950	9·633969	5 29	10·366031	10·036919	5 5	9·963081	50	30
18	12	9·597196	6 29	10·402804	9·634143	6 35	10·365857	10·036946	6 5	9·963054	48	42
30	14	9·597343	7 34	10·402657	9·634316	7 40	10·365684	10·036973	7 6	9·963027	46	30
19	16	9·597490	8 39	10·402510	9·634490	8 46	10·365510	10·037001	8 7	9·962999	44	41
30	18	9·597636	9 44	10·402364	9·634664	9 52	10·365336	10·037028	9 8	9·962972	42	30
20	20	9·597783	10 49	10·402217	9·634838	10 58	10·365162	10·037055	10 9	9·962945	40	40
30	22	9·597929	11 54	10·402071	9·635011	11 64	10·364989	10·037082	11 10	9·962918	38	30
21	24	9·598075	12 58	10·401925	9·635185	12 69	10·364815	10·037110	12 11	9·962890	36	39
30	26	9·598222	13 63	10·401778	9·635359	13 75	10·364641	10·037137	13 12	9·962863	34	30
22	28	9·598368	14 68	10·401632	9·635532	14 81	10·364468	10·037164	14 13	9·962836	32	38
30	30	9·598514	15 73	10·401486	9·635706	15 87	10·364294	10·037191	15 14	9·962809	30	30
23	32	9·598660	16 78	10·401340	9·635879	16 92	10·364121	10·037219	16 15	9·962781	28	37
30	34	9·598806	17 83	10·401194	9·636052	17 98	10·363948	10·037246	17 15	9·962754	26	30
24	36	9·598952	18 88	10·401048	9·636226	18 104	10·363774	10·037273	18 16	9·962727	24	36
30	38	9·599098	19 93	10·400902	9·636399	19 110	10·363601	10·037301	19 17	9·962699	22	30
25	40	9·599244	20 98	10·400756	9·636572	20 116	10·363428	10·037328	20 18	9·962672	20	35
30	42	9·599390	21 102	10·400610	9·636745	21 121	10·363255	10·037355	21 19	9·962645	18	30
26	44	9·599536	22 107	10·400464	9·636919	22 127	10·363081	10·037383	22 20	9·962617	16	34
30	46	9·599681	23 112	10·400319	9·637092	23 133	10·362908	10·037410	23 21	9·962590	14	30
27	48	9·599827	24 117	10·400173	9·637265	24 139	10·362735	10·037438	24 22	9·962562	12	33
30	50	9·599973	25 122	10·400027	9·637438	25 144	10·362562	10·037465	25 23	9·962535	10	30
28	52	9·600118	26 127	10·399882	9·637611	26 150	10·362389	10·037492	26 24	9·962508	8	32
30	54	9·600264	27 131	10·399736	9·637783	27 156	10·362217	10·037520	27 25	9·962480	6	30
29	56	9·600409	28 136	10·399591	9·637956	28 162	10·362044	10·037547	28 25	9·962453	4	31
30	58	9·600554	29 141	10·399446	9·638129	29 168	10·361871	10·037575	29 26	9·962425	2	30
30	34	9·600700	30 146	10·399300	9·638302	30 173	10·361698	10·037602	30 27	9·962398	0	30
′ ″	m.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m.	′ ″

66° — 4h 26m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

$1^h\ 34^m$ — 23°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·600700		10·399300	9·638302		10·361698	10·037602		9·962398	26	30
30	2	9·600845	1″ 5	10·399155	9·638475	1″ 6	10·361525	10·037630	1″ 1	9·962370	58	30
31	4	9·600990	2 10	10·399010	9·638647	2 11	10·361353	10·037657	2 2	9·962343	56	29
30	6	9·601135	3 14	10·398865	9·638820	3 17	10·361180	10·037685	3 3	9·962315	54	30
32	8	9·601280	4 19	10·398720	9·638992	4 23	10·361008	10·037712	4 4	9·962288	52	28
30	10	9·601425	5 24	10·398575	9·639165	5 29	10·360835	10·037740	5 5	9·962260	50	30
33	12	9·601570	6 29	10·398430	9·639337	6 34	10·360663	10·037767	6 6	9·962233	48	27
30	14	9·601715	7 34	10·398285	9·639510	7 40	10·360490	10·037795	7 6	9·962205	46	30
34	16	9·601860	8 38	10·398140	9·639682	8 46	10·360318	10·037822	8 7	9·962178	44	26
30	18	9·602005	9 43	10·397995	9·639855	9 52	10·360145	10·037850	9 8	9·962150	42	30
35	20	9·602150	10 48	10·397850	9·640027	10 57	10·359973	10·037877	10 9	9·962123	40	25
30	22	9·602294	11 53	10·397706	9·640199	11 63	10·359801	10·037905	11 10	9·962095	38	30
36	24	9·602439	12 58	10·397561	9·640371	12 69	10·359629	10·037933	12 11	9·962067	36	24
30	26	9·602583	13 62	10·397417	9·640544	13 74	10·359456	10·037960	13 12	9·962040	34	30
37	28	9·602728	14 67	10·397272	9·640716	14 80	10·359284	10·037988	14 13	9·962012	32	23
30	30	9·602872	15 72	10·397128	9·640888	15 86	10·359112	10·038015	15 14	9·961985	30	30
38	32	9·603017	16 77	10·396983	9·641060	16 92	10·358940	10·038043	16 15	9·961957	28	22
30	34	9·603161	17 82	10·396839	9·641232	17 97	10·358768	10·038071	17 16	9·961929	26	30
39	36	9·603305	18 87	10·396695	9·641404	18 103	10·358596	10·038098	18 17	9·961902	24	21
30	38	9·603449	19 92	10·396551	9·641575	19 109	10·358425	10·038126	19 17	9·961874	22	30
40	40	9·603594	20 96	10·396406	9·641747	20 115	10·358253	10·038154	20 18	9·961846	20	20
30	42	9·603738	21 101	10·396262	9·641919	21 120	10·358081	10·038181	21 19	9·961819	18	30
41	44	9·603882	22 106	10·396118	9·642091	22 126	10·357909	10·038209	22 20	9·961791	16	19
30	46	9·604026	23 111	10·395974	9·642263	23 132	10·357737	10·038237	23 21	9·961763	14	30
42	48	9·604170	24 115	10·395830	9·642434	24 138	10·357566	10·038265	24 22	9·961735	12	18
30	50	9·604313	25 120	10·395687	9·642606	25 143	10·357394	10·038292	25 23	9·961708	10	30
43	52	9·604457	26 125	10·395543	9·642777	26 149	10·357223	10·038320	26 24	9·961680	8	17
30	54	9·604601	27 130	10·395399	9·642949	27 155	10·357051	10·038348	27 25	9·961652	6	30
44	56	9·604745	28 134	10·395255	9·643120	28 160	10·356880	10·038376	28 26	9·961624	4	16
30	58	9·604888	29 139	10·395112	9·643292	29 166	10·356708	10·038403	29 27	9·961597	2	30
45	**35**	9·605032	30 144	10·394968	9·643463	30 172	10·356537	10·038431	30 28	9·961569	**25**	15
30	2	9·605176	1 5	10·394824	9·643634	1 6	10·356366	10·038459	1 1	9·961541	58	30
46	4	9·605319	2 10	10·394681	9·643806	2 11	10·356194	10·038487	2 2	9·961513	56	14
30	6	9·605462	3 14	10·394538	9·643977	3 17	10·356023	10·038515	3 3	9·961485	64	30
47	8	9·605606	4 19	10·394394	9·644148	4 23	10·355852	10·038542	4 4	9·961458	62	13
30	10	9·605749	5 24	10·394251	9·644319	5 28	10·355681	10·038570	5 5	9·961430	60	30
48	12	9·605892	6 29	10·394108	9·644490	6 34	10·355510	10·038598	6 6	9·961402	48	12
30	14	9·606035	7 33	10·393965	9·644661	7 40	10·355339	10·038626	7 7	9·961374	46	30
49	16	9·606179	8 38	10·393821	9·644832	8 46	10·355168	10·038654	8 7	9·961346	44	11
30	18	9·606322	9 43	10·393678	9·645003	9 51	10·354997	10·038682	9 8	9·961318	42	30
50	20	9·606465	10 48	10·393535	9·645174	10 57	10·354826	10·038710	10 9	9·961290	40	10
30	22	9·606608	11 52	10·393392	9·645345	11 63	10·354655	10·038737	11 10	9·961263	38	30
51	24	9·606751	12 57	10·393249	9·645516	12 68	10·354484	10·038765	12 11	9·961235	36	9
30	26	9·606893	13 62	10·393107	9·645687	13 74	10·354313	10·038793	13 12	9·961207	34	30
52	28	9·607036	14 67	10·392964	9·645857	14 80	10·354143	10·038821	14 13	9·961179	32	8
30	30	9·607179	15 71	10·392821	9·646028	15 85	10·353972	10·038849	15 14	9·961151	30	30
53	32	9·607322	16 76	10·392678	9·646199	16 91	10·353801	10·038877	16 15	9·961123	28	7
30	34	9·607464	17 81	10·392536	9·646369	17 97	10·353631	10·038905	17 16	9·961095	26	30
54	36	9·607607	18 86	10·392393	9·646540	18 102	10·353460	10·038933	18 17	9·961067	24	6
30	38	9·607749	19 90	10·392251	9·646710	19 108	10·353290	10·038961	19 18	9·961039	22	30
55	40	9·607892	20 95	10·392108	9·646881	20 114	10·353119	10·038989	20 19	9·961011	20	5
30	42	9·608034	21 100	10·391966	9·647051	21 119	10·352949	10·039017	21 20	9·960983	18	30
56	44	9·608177	22 105	10·391823	9·647222	22 125	10·352778	10·039045	22 20	9·960955	16	4
30	46	9·608319	23 110	10·391681	9·647392	23 131	10·352608	10·039073	23 21	9·960927	14	30
57	48	9·608461	24 114	10·391539	9·647562	24 137	10·352438	10·039101	24 22	9·960899	12	3
30	50	9·608603	25 119	10·391397	9·647733	25 142	10·352267	10·039129	25 23	9·960871	10	30
58	52	9·608745	26 124	10·391255	9·647903	26 148	10·352097	10·039157	26 24	9·960843	8	2
30	54	9·608887	27 128	10·391113	9·648073	27 154	10·351927	10·039186	27 25	9·960814	6	30
59	56	9·609029	28 133	10·390971	9·648243	28 159	10·351757	10·039214	28 26	9·960786	4	1
30	58	9·609171	29 138	10·390829	9·648413	29 165	10·351587	10·039242	29 27	9·960758	2	30
60	**36**	9·609313	30 143	10·390687	9·648583	30 171	10·351417	10·039270	30 28	9·960730	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

66° — $4^h\ 24^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.												
$1^h\ 36^m$						24°						
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·609313		10·390687	9·648583		10·351417	10·039270		9·960730	24	60
30	2	9·609455	1″ 5	10·390545	9·648753	1″ 6	10·351247	10·039298	1″ 1	9·960702	58	30
1	4	9·609597	2 9	10·390403	9·648923	2 11	10·351077	10·039326	2 2	9·960674	56	59
30	6	9·609739	3 14	10·390261	9·649093	3 17	10·350907	10·039354	3 3	9·960646	54	30
2	8	9·609880	4 19	10·390120	9·649263	4 23	10·350737	10·039382	4 4	9·960618	52	58
30	10	9·610022	5 23	10·389978	9·649433	5 28	10·350567	10·039411	5 5	9·960589	50	30
3	12	9·610164	6 28	10·389836	9·649602	6 34	10·350398	10·039439	6 6	9·960561	48	57
30	14	9·610305	7 33	10·389695	9·649772	7 39	10·350228	10·039467	7 7	9·960533	46	30
4	16	9·610447	8 38	10·389553	9·649942	8 45	10·350058	10·039495	8 8	9·960505	44	56
30	18	9·610588	9 42	10·389412	9·650111	9 51	10·349889	10·039523	9 8	9·960477	42	30
5	20	9·610729	10 47	10·389271	9·650281	10 56	10·349719	10·039552	10 9	9·960448	40	55
30	22	9·610871	11 52	10·389129	9·650450	11 62	10·349550	10·039580	11 10	9·960420	38	30
6	24	9·611012	12 56	10·388988	9·650620	12 68	10·349380	10·039608	12 11	9·960392	36	54
30	26	9·611153	13 61	10·388847	9·650789	13 73	10·349211	10·039636	13 12	9·960364	34	30
7	28	9·611294	14 66	10·388706	9·650959	14 79	10·349041	10·039665	14 13	9·960335	32	53
30	30	9·611435	15 71	10·388565	9·651128	15 85	10·348872	10·039693	15 14	9·960307	30	30
8	32	9·611576	16 75	10·388424	9·651297	16 90	10·348703	10·039721	16 15	9·960279	28	52
30	34	9·611717	17 80	10·388283	9·651467	17 96	10·348533	10·039750	17 16	9·960250	26	30
9	36	9·611858	18 85	10·388142	9·651636	18 102	10·348364	10·039778	18 17	9·960222	24	51
30	38	9·611999	19 89	10·388001	9·651805	19 107	10·348195	10·039806	19 18	9·960194	22	30
10	40	9·612140	20 94	10·387860	9·651974	20 113	10·348026	10·039835	20 19	9·960165	20	50
30	42	9·612280	21 99	10·387720	9·652143	21 118	10·347857	10·039863	21 20	9·960137	18	30
11	44	9·612421	22 103	10·387579	9·652312	22 124	10·347688	10·039891	22 21	9·960109	16	49
30	46	9·612562	23 108	10·387438	9·652481	23 130	10·347519	10·039920	23 22	9·960080	14	30
12	48	9·612702	24 113	10·387298	9·652650	24 155	10·347350	10·039948	24 23	9·960052	12	48
30	50	9·612843	25 117	10·387157	9·652819	25 141	10·347181	10·039976	25 23	9·960024	10	30
13	52	9·612983	26 122	10·387017	9·652988	26 147	10·347012	10·040005	26 24	9·959995	8	47
30	54	9·613124	27 127	10·386876	9·653157	27 152	10·346843	10·040033	27 25	9·959967	6	30
14	56	9·613264	28 132	10·386736	9·653326	28 158	10·346674	10·040062	28 26	9·959938	4	46
30	58	9·613404	29 136	10·386596	9·653494	29 164	10·346506	10·040090	29 27	9·959910	2	30
15	**37**	9·613545	30 141	10·386455	9·653663	30 169	10·346337	10·040118	30 28	9·959882	**23**	45
30	2	9·613685	1 5	10·386315	9·653832	1 6	10·346168	10·040147	1 1	9·959853	58	30
16	4	9·613825	2 9	10·386175	9·654000	2 11	10·346000	10·040175	2 2	9·959825	56	44
30	6	9·613965	3 14	10·386035	9·654169	3 17	10·345831	10·040204	3 3	9·959796	54	30
17	8	9·614105	4 19	10·385895	9·654337	4 22	10·345663	10·040232	4 4	9·959768	52	43
30	10	9·614245	5 23	10·385755	9·654506	5 28	10·345494	10·040261	5 5	9·959739	50	30
18	12	9·614385	6 28	10·385615	9·654674	6 34	10·345326	10·040289	6 6	9·959711	48	42
30	14	9·614525	7 32	10·385475	9·654843	7 39	10·345157	10·040318	7 7	9·959682	46	30
19	16	9·614665	8 37	10·385335	9·655011	8 45	10 344989	10·040346	8 8	9·959654	44	41
30	18	9·614804	9 42	10·385196	9·655179	9 50	10·344821	10·040375	9 9	9·959625	42	30
20	20	9·614944	10 46	10·385056	9·655348	10 56	10·344652	10·040404	10 10	9·959596	40	40
30	22	9·615084	11 51	10·384916	9·655516	11 62	10·344484	10·040432	11 10	9·959568	38	30
21	24	9·615223	12 56	10·384777	9·655684	12 67	10·344316	10·040461	12 11	9·959539	36	39
30	26	9·615363	13 61	10·384637	9·655852	13 73	10·344148	10·040489	13 12	9·959511	34	30
22	28	9·615502	14 65	10·384498	9·656020	14 78	10·343980	10·040518	14 13	9·959482	32	38
30	30	9·615642	15 70	10·384358	9·656188	15 84	10·343812	10·040547	15 14	9·959453	30	30
23	32	9·615781	16 75	10·384219	9·656356	16 90	10·343644	10·040575	16 15	9·959425	28	37
30	34	9·615921	17 79	10·384079	9·656524	17 95	10·343476	10·040604	17 16	9·959396	26	30
24	36	9·616060	18 84	10·383940	9·656692	18 101	10·343308	10·040632	18 17	9·959368	24	36
30	38	9·616199	19 89	10·383801	9·656860	19 106	10·343140	10·040661	19 18	9·959339	22	30
25	40	9·616338	20 93	10·383662	9·657028	20 112	10·342972	10·040690	20 19	9·959310	20	35
30	42	9·616477	21 98	10·383523	9·657196	21 118	10·342804	10·040718	21 20	9·959282	18	30
26	44	9·616616	22 103	10·383384	9·657364	22 123	10·342636	10·040747	22 21	9·959253	16	34
30	46	9·616755	23 107	10·383245	9·657531	23 129	10·342469	10·040776	23 22	9·959224	14	30
27	48	9·616894	24 112	10·383106	9·657699	24 134	10·342301	10·040805	24 23	9·959195	12	33
30	50	9·617033	25 117	10·382967	9·657867	25 140	10·342133	10·040833	25 24	9·959167	10	30
28	52	9·617172	26 122	10·382828	9·658034	26 146	10·341966	10·040862	26 25	9·959138	8	32
30	54	9·617311	27 126	10·382689	9·658202	27 151	10·341798	10·040891	27 26	9·959109	6	30
29	56	9·617450	28 131	10·382550	9·658369	28 157	10·341631	10·040920	28 27	9·959080	4	31
30	58	9·617588	29 135	10·382412	9·658537	29 162	10·341463	10·040948	29 28	9·959052	2	30
30	**38**	9·617727	30 140	10·382273	9·658704	30 168	10·341296	10·040977	30 29	9·959023	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
						65°						$4^h\ 22^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1h 38m — 24°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·617727		10·382273	9·658704		10·341296	10·040977		9·959023	22	30
30	2	9·617866	1″ 5	10·382134	9·658871	1″ 6	10·341129	10·041006	1″ 1	9·958994	58	30
31	4	9·618004	2 9	10·381996	9·659039	2 11	10·340961	10·041035	2 2	9·958965	56	29
30	6	9·618143	3 14	10·381857	9·659206	3 17	10·340794	10·041063	3 3	9·958937	54	30
32	8	9·618281	4 18	10·381719	9·659373	4 22	10·340627	10·041092	4 4	9·958908	52	28
30	10	9·618419	5 23	10·381581	9·659540	5 28	10·340460	10·041121	5 5	9·958879	50	30
33	12	9·618558	6 28	10·381442	9·659708	6 33	10·340292	10·041150	6 6	9·958850	48	27
30	14	9·618696	7 32	10·381304	9·659875	7 39	10·340125	10·041179	7 7	9·958821	46	30
34	16	9·618834	8 37	10·381166	9·660042	8 44	10·339958	10·041208	8 8	9·958792	44	26
30	18	9·618972	9 41	10·381028	9·660209	9 50	10·339791	10·041237	9 9	9·958763	42	30
35	20	9·619110	10 46	10·380890	9·660376	10 56	10·339624	10·041266	10 10	9·958734	40	25
30	22	9·619248	11 50	10·380752	9·660543	11 61	10·339457	10·041294	11 11	9·958706	38	30
36	24	9·619386	12 55	10·380614	9·660710	12 67	10·339290	10·041323	12 12	9·958677	36	24
30	26	9·619524	13 59	10·380476	9·660877	13 72	10·339123	10·041352	13 12	9·953648	34	30
37	28	9·619662	14 64	10·380338	9·661043	14 78	10·338957	10·041381	14 13	9·958619	32	23
30	30	9·619800	15 69	10·380200	9·661210	15 83	10·338790	10·041410	15 14	9·958590	30	30
38	32	9·619938	16 73	10·380062	9·661377	16 89	10·338623	10·041439	16 15	9·958561	28	22
30	34	9·620076	17 78	10·379924	9·661544	17 95	10·338456	10·041468	17 16	9·958532	26	30
39	36	9·620213	18 83	10·379787	9·661710	18 100	10·338290	10·041497	18 17	9·958503	24	21
30	38	9·620351	19 87	10·379649	9·661877	19 106	10·338123	10·041526	19 18	9·958474	22	30
40	40	9·620488	20 92	10·379512	9·662043	20 111	10·337957	10·041555	20 19	9·958445	20	20
30	42	9·620626	21 96	10·379374	9·662210	21 117	10·337790	10·041584	21 20	9·958416	18	30
41	44	9·620763	22 101	10·379237	9·662376	22 122	10·337624	10·041613	22 21	9·958387	16	19
30	46	9·620901	23 105	10·379099	9·662543	23 128	10·337457	10·041642	23 22	9·958358	14	30
42	48	9·621038	24 110	10·378962	9·662709	24 133	10·337291	10·041671	24 23	9·958329	12	18
30	50	9·621175	25 114	10·378825	9·662876	25 139	10·337124	10·041700	25 24	9·958300	10	30
43	52	9·621313	26 119	10·378687	9·663042	26 145	10·336958	10·041729	26 25	9·958271	8	17
30	54	9·621450	27 124	10·378550	9·663208	27 150	10·336792	10·041758	27 26	9·958242	6	30
44	56	9·621587	28 129	10·378413	9·663375	28 156	10·336625	10·041787	28 27	9·958213	4	16
30	58	9·621724	29 133	10·378276	9·663541	29 161	10·336459	10·041817	29 28	9·958183	2	30
45	39	9·621861	30 138	10·378139	9·663707	30 167	10·336293	10·041846	30 29	9·958154	21	15
30	2	9·621998	1 5	10·378002	9·663873	1 6	10·336127	10·041875	1 1	9·958125	58	30
46	4	9·622135	2 9	10·377865	9·664039	2 11	10·335961	10·041904	2 2	9·958096	56	14
30	6	9·622272	3 14	10·377728	9·664205	3 17	10·335795	10·041933	3 3	9·958067	54	30
47	8	9·622409	4 18	10·377591	9·664371	4 22	10·335629	10·041962	4 4	9·958038	52	13
30	10	9·622546	5 23	10·377454	9·664537	5 28	10·335463	10·041991	5 5	9·958009	50	30
48	12	9·622682	6 27	10·377318	9·664703	6 33	10·335297	10·042021	6 6	9·957979	48	12
30	14	9·622819	7 32	10·377181	9·664869	7 39	10·335131	10·042050	7 7	9·957950	46	30
49	16	9·622956	8 36	10·377044	9·665035	8 44	10·334965	10·042079	8 8	9·957921	44	11
30	18	9·623092	9 41	10·376908	9·665200	9 50	10·334800	10·042108	9 9	9·957892	42	30
50	20	9·623229	10 45	10·376771	9·665366	10 55	10·334634	10·042137	10 10	9·957863	40	10
30	22	9·623365	11 50	10·376635	9·665532	11 61	10·334468	10·042167	11 11	9·957833	38	30
51	24	9·623502	12 54	10·376498	9·665698	12 66	10·334302	10·042196	12 12	9·957804	36	9
30	26	9·623638	13 59	10·376362	9·665863	13 72	10·334137	10·042225	13 13	9·957775	34	30
52	28	9·623774	14 63	10·376226	9·666029	14 77	10·333971	10·042254	14 14	9·957746	32	8
30	30	9·623911	15 68	10·376089	9·666194	15 83	10·333806	10·042284	15 15	9·957716	30	30
53	32	9·624047	16 72	10·375953	9·666360	16 88	10·333640	10·042313	16 16	9·957687	28	7
30	34	9·624183	17 77	10·375817	9·666525	17 94	10·333475	10·042342	17 17	9·957658	26	30
54	36	9·624319	18 82	10·375681	9·666691	18 99	10·333309	10·042372	18 18	9·957628	24	6
30	38	9·624455	19 86	10·375545	9·666856	19 105	10·333144	10·042401	19 19	9·957599	22	30
55	40	9·624591	20 91	10·375409	9·667021	20 110	10·332979	10·042430	20 20	9·957570	20	5
30	42	9·624727	21 95	10·375273	9·667187	21 116	10·332813	10·042460	21 20	9·957540	18	30
56	44	9·624863	22 100	10·375137	9·667352	22 121	10·332648	10·042489	22 21	9·957511	16	4
30	46	9·624999	23 104	10·375001	9·667517	23 127	10·332483	10·042518	23 22	9·957482	14	30
57	48	9·625135	24 109	10·374865	9·667682	24 132	10·332318	10·042548	24 23	9·957452	12	3
30	50	9·625270	25 113	10·374730	9·667847	25 138	10·332153	10·042577	25 24	9·957423	10	30
58	52	9·625406	26 118	10·374594	9·668013	26 144	10·331987	10·042607	26 25	9·957393	8	2
30	54	9·625542	27 123	19·374458	9·668178	27 149	10·331822	10·042636	27 26	9·957364	6	30
59	56	9·625677	28 127	10·374323	9·668343	28 155	10·331657	10·042665	28 27	9·957335	4	1
30	58	9·625813	29 132	10·374187	9·668508	29 160	10·331492	10·042695	29 28	9·957305	2	30
60	60	9·625948	30 136	10·374052	9·668672	30 166	10·331327	10·042724	30 29	9·957276	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

65° — 4h 20m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1ʰ 40ᵐ — 25°

′ ″	m. s.	Sine	Parts	Coser.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·625948		10·374052	9·668673		10·331327	10·042724		9·957276	20	60
30	2	9·626084	1″ 4	10·373916	9·668837	1″ 5	10·331163	10·042754	1″ 1	9·957246	58	30
1	4	9·626219	2 9	10·373781	9·669002	2 11	10·330998	10·042783	2 2	9·957217	56	59
30	6	9·626354	3 13	10·373646	9·669167	3 16	10·330833	10·042813	3 3	9·957187	54	30
2	8	9·626490	4 18	10·373510	9·669332	4 22	10·330668	10·042842	4 4	9·957158	52	58
30	10	9·626625	5 22	10·373375	9·669497	5 27	10·330503	10·042872	5 5	9·957128	50	30
3	12	9·626760	6 27	10·373240	9·669661	6 33	10·330339	10·042901	6 6	9·957099	48	57
30	14	9·626895	7 31	10·373105	9·669826	7 38	10·330174	10·042931	7 7	9·957069	46	30
4	16	9·627030	8 36	10·372970	9·669991	8 44	10·330009	10·042960	8 8	9·957040	44	56
30	18	9·627165	9 40	10·372835	9·670155	9 49	10·329845	10·042990	9 9	9·957010	42	30
5	20	9·627300	10 45	10·372700	9·670320	10 55	10·329680	10·043019	10 10	9·956981	40	55
30	22	9·627435	11 49	10·372565	9·670484	11 60	10·329516	10·043049	11 11	9·956951	38	30
6	24	9·627570	12 54	10·372430	9·670649	12 66	10·329351	10·043079	12 12	9·956921	36	54
30	26	9·627705	13 58	10·372295	9·670813	13 71	10·329187	10·043108	13 13	9·956892	34	30
7	28	9·627840	14 63	10·372160	9·670977	14 77	10·329023	10·043138	14 14	9·956862	32	53
30	30	9·627974	15 67	10·372026	9·671142	15 82	10·328858	10·043167	15 15	9·956833	30	30
8	32	9·628109	16 72	10·371891	9·671306	16 88	10·328694	10·043197	16 16	9·956803	28	52
30	34	9·628244	17 76	10·371756	9·671470	17 93	10·328530	10·043227	17 17	9·956773	26	30
9	36	9·628378	18 81	10·371622	9·671635	18 99	10·328365	10·043256	18 18	9·956744	24	51
30	38	9·628513	19 85	10·371487	9·671799	19 104	10·328201	10·043286	19 19	9·956714	22	30
10	40	9·628647	20 90	10·371353	9·671963	20 110	10·328037	10·043316	20 20	9·956684	20	50
30	42	9·628782	21 94	10·371218	9·672127	21 115	10·327873	10·043345	21 21	9·956655	18	30
11	44	9·628916	22 99	10·371084	9·672291	22 121	10·327709	10·043375	22 22	9·956625	16	49
30	46	9·629050	23 103	10·370950	9·672455	23 126	10·327545	10·043405	23 23	9·956595	14	30
12	48	9·629185	24 108	10·370815	9·672619	24 132	10·327381	10·043434	24 24	9·956566	12	48
30	50	9·629319	25 112	10·370681	9·672783	25 137	10·327217	10·043464	25 25	9·956536	10	30
13	52	9·629453	26 117	10·370547	9·672947	26 142	10·327053	10·043494	26 26	9·956506	8	47
30	54	9·629587	27 121	10·370413	9·673111	27 148	10·326889	10·043524	27 27	9·956476	6	30
14	56	9·629721	28 126	10·370279	9·673274	28 153	10·326726	10·043553	28 28	9·956447	4	46
30	58	9·629855	29 130	10·370145	9·673438	29 159	10·326562	10·043583	29 29	9·956417	2	30
15	41	9·629989	30 135	10·370011	9·673602	30 164	10·326398	10·043613	30 30	9·956387	19	45
30	2	9·630123	1 4	10·369877	9·673766	1 5	10·326234	10·043643	1 1	9·956357	58	30
16	4	9·630257	2 9	10·369743	9·673929	2 11	10·326071	10·043673	2 2	9·956327	56	44
30	6	9·630391	3 13	10·369609	9·674093	3 16	10·325907	10·043702	3 3	9·956298	54	30
17	8	9·630524	4 18	10·369476	9·674257	4 22	10·325743	10·043732	4 4	9·956268	52	43
30	10	9·630658	5 22	10·369342	9·674420	5 27	10·325580	10·043762	5 5	9·956238	50	30
18	12	9·630792	6 27	10·369208	9·674584	6 33	10·325416	10·043792	6 6	9·956208	48	42
30	14	9·630925	7 31	10·369075	9·674747	7 38	10·325253	10·043822	7 7	9·956178	46	30
19	16	9·631059	8 36	10·368941	9·674911	8 44	10·325089	10·043852	8 8	9·956148	44	41
30	18	9·631192	9 40	10·368808	9·675074	9 49	10·324926	10·043882	9 9	9·956118	42	30
20	20	9·631326	10 44	10·368674	9·675237	10 54	10·324763	10·043911	10 10	9·956089	40	40
30	22	9·631459	11 49	10·368541	9·675401	11 60	10·324599	10·043941	11 11	9·956059	38	30
21	24	9·631593	12 53	10·368407	9·675564	12 65	10·324436	10·043971	12 12	9·956029	36	39
30	26	9·631726	13 58	10·368274	9·675727	13 71	10·324273	10·044001	13 13	9·955999	34	30
22	28	9·631859	14 62	10·368141	9·675890	14 76	10·324110	10·044031	14 14	9·955969	32	38
30	30	9·631992	15 67	10·368008	9·676053	15 82	10·323947	10·044061	15 15	9·955939	30	30
23	32	9·632125	16 71	10·367875	9·676217	16 87	10·323783	10·044091	16 16	9·955909	28	37
30	34	9·632259	17 75	10·367741	9·676380	17 92	10·323620	10·044121	17 17	9·955879	26	30
24	36	9·632392	18 80	10·367608	9·676543	18 98	10·323457	10·044151	18 18	9·955849	24	36
30	38	9·632525	19 84	10·367475	9·676706	19 103	10·323294	10·044181	19 19	9·955819	22	30
25	40	9·632658	20 89	10·367342	9·676869	20 109	10·323131	10·044211	20 20	9·955789	20	35
30	42	9·632790	21 93	10·367208	9·677032	21 114	10·322968	10·044241	21 21	9·955759	18	30
26	44	9·632923	22 98	10·367077	9·677194	22 120	10·322806	10·044271	22 22	9·955729	16	34
30	46	9·633056	23 102	10·366944	9·677357	23 125	10·322643	10·044301	23 23	9·955699	14	30
27	48	9·633189	24 107	10·366811	9·677520	24 131	10·322480	10·044331	24 24	9·955669	12	33
30	50	9·633322	25 111	10·366678	9·677683	25 136	10·322317	10·044361	25 25	9·955639	10	30
28	52	9·633454	26 116	10·366546	9·677846	26 141	10·322154	10·044391	26 26	9·955609	8	32
30	54	9·633587	27 120	10·366413	9·678008	27 147	10·321992	10·044421	27 27	9·955579	6	30
29	56	9·633719	28 125	10·366281	9·678171	28 152	10·321829	10·044452	28 28	9·955548	4	31
30	58	9·633852	29 129	10·366148	9·678334	29 158	10·321666	10·044482	29 29	9·955518	2	30
30	42	9·633984	30 133	10·366016	9·678496	30 163	10·321504	10·044512	30 30	9·955488	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

64° — 4ʰ 18ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1h 42m — 25°

′ ″	m. s	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s	′ ″
30	0	9·633984		10·366016	9·678496		10·321504	10·044512		9·955488	18	30
30	2	9·634117	1″ 4	10·365883	9·678659	1″ 5	10·321341	10·044542	1″ 1	9·955458	58	30
31	4	9·634249	2 9	10·365751	9·678821	2 11	10·321179	10·044572	2 2	9·955428	56	29
30	6	9·634381	3 13	10·365619	9·678984	3 16	10·321016	10·044602	3 3	9·955398	54	30
32	8	9·634514	4 18	10·365486	9·679146	4 22	10·320854	10·044632	4 4	9·955368	52	28
30	10	9·634646	5 22	10·365354	9·679308	5 27	10·320692	10·044663	5 5	9·955337	50	30
33	12	9·634778	6 26	10·365222	9·679471	6 32	10·320529	10·044693	6 6	9·955307	48	27
30	14	9·634910	7 31	10·365090	9·679633	7 38	10·320367	10·044723	7 7	9·955277	46	30
34	16	9·635042	8 35	10·364958	9·679795	8 43	10·320205	10·044753	8 8	9·955247	44	26
30	18	9·635174	9 40	10·364826	9·679958	9 49	10·320042	10·044783	9 9	9·955217	42	30
35	20	9·635306	10 44	10·364694	9·680120	10 54	10·319880	10·044814	10 10	9·955186	40	25
30	22	9·635438	11 48	10·364562	9·680282	11 59	10·319718	10·044844	11 11	9·955156	38	30
36	24	9·635570	12 53	10·364430	9·680444	12 65	10·319556	10·044874	12 12	9·955126	36	24
30	26	9·635702	13 57	10·364298	9·680606	13 70	10·319394	10·044904	13 13	9·955096	34	30
37	28	9·635834	14 61	10·364166	9·680768	14 76	10·319232	10·044935	14 14	9·955065	32	23
30	30	9·635965	15 66	10·364035	9·680930	15 81	10·319070	10·044965	15 15	9·955035	30	30
38	32	9·636097	16 70	10·363903	9·681092	16 86	10·318908	10·044995	16 16	9·955005	28	22
30	34	9·636229	17 75	10·363771	9·681254	17 92	10·318746	10·045026	17 17	9·954974	26	30
39	36	9·636360	18 79	10·363640	9·681416	18 97	10·318584	10·045056	18 18	9·954944	24	21
30	38	9·636492	19 83	10·363508	9·681578	19 103	10·318422	10·045086	19 19	9·954914	22	30
40	40	9·636623	20 88	10·363377	9·681740	20 108	10·318260	10·045117	20 20	9·954883	20	20
30	42	9·636754	21 92	10·363246	9·681901	21 113	10·318099	10·045147	21 21	9·954853	18	30
41	44	9·636886	22 96	10·363114	9·682063	22 119	10·317937	10·045177	22 22	9·954823	16	19
30	46	9·637017	23 101	10·362983	9·682225	23 124	10·317775	10·045208	23 23	9·954792	14	30
42	48	9·637148	24 105	10·362852	9·682387	24 130	10·317613	10·045238	24 24	9·954762	12	18
30	50	9·637280	25 110	10·362720	9·682548	25 135	10·317452	10·045268	25 25	9·954732	10	30
43	52	9·637411	26 114	10·362589	9·682710	26 140	10·317290	10·045299	26 26	9·954701	8	17
30	54	9·637542	27 119	10·362458	9·682871	27 146	10·317129	10·045329	27 27	9·954671	6	30
44	56	9·637673	28 123	10·362327	9·683033	28 151	10·316967	10·045360	28 28	9·954640	4	16
30	58	9·637804	29 127	10·362196	9·683194	29 157	10·316806	10·045390	29 29	9·954610	2	30
45	43	9·637935	30 132	10·362065	9·683356	30 162	10·316644	10·045421	30 30	9·954579	17	15
30	2	9·638066	1 4	10·361934	9·683517	1 5	10·316483	10·045451	1 1	9·954549	58	30
46	4	9·638197	2 9	10·361803	9·683679	2 11	10·316321	10·045482	2 2	9·954518	56	14
30	6	9·638328	3 13	10·361672	9·683840	3 16	10·316160	10·045512	3 3	9·954488	54	30
47	8	9·638458	4 17	10·361542	9·684001	4 21	10·315999	10·045543	4 4	9·954457	52	13
30	10	9·638589	5 22	10·361411	9·684162	5 27	10·315838	10·045573	5 5	9·954427	50	30
48	12	9·638720	6 26	10·361280	9·684324	6 32	10·315676	10·045604	6 6	9·954396	48	12
30	14	9·638851	7 30	10·361149	9·684485	7 38	10·315515	10·045634	7 7	9·954366	46	30
49	16	9·638981	8 35	10·361019	9·684646	8 43	10·315354	10·045665	8 8	9·954335	44	11
30	18	9·639112	9 39	10·360888	9·684807	9 48	10·315193	10·045695	9 9	9·954305	42	30
50	20	9·639242	10 43	10·360758	9·684968	10 54	10·315032	10·045726	10 10	9·954274	40	10
30	22	9·639373	11 48	10·360627	9·685129	11 59	10·314871	10·045757	11 11	9·954243	38	30
51	24	9·639503	12 52	10·360497	9·685290	12 64	10·314710	10·045787	12 12	9·954213	36	9
30	26	9·639633	13 56	10·360367	9·685451	13 70	10·314549	10·045818	13 13	9·954182	34	30
52	28	9·639764	14 61	10·360236	9·685612	14 75	10·314388	10·045848	14 14	9·954152	32	8
30	30	9·639894	15 65	10·360106	9·685773	15 80	10·314227	10·045879	15 15	9·954121	30	30
53	32	9·640024	16 69	10·359976	9·685934	16 86	10·314066	10·045910	16 16	9·954090	28	7
30	34	9·640154	17 74	10·359846	9·686095	17 91	10·313905	10·045940	17 17	9·954060	26	30
54	36	9·640284	18 78	10·359716	9·686255	18 96	10·313745	10·045971	18 18	9·954029	24	6
30	38	9·640414	19 82	10·359586	9·686416	19 102	10·313584	10·046002	19 19	9·953998	22	30
55	40	9·640544	20 87	10·359456	9·686577	20 107	10·313423	10·046022	20 20	9·953968	20	5
30	42	9·640674	21 91	10·359326	9·686737	21 113	10·313263	10·046063	21 21	9·953937	18	30
56	44	9·640804	22 95	10·359196	9·686898	22 118	10·313102	10·046094	22 22	9·953906	16	4
30	46	9·640934	23 100	10·359066	9·687059	23 123	10·312941	10·046124	23 23	9·953876	14	30
57	48	9·641064	24 104	10·358936	9·687219	24 129	10·312781	10·046155	24 24	9·953845	12	3
30	50	9·641194	25 109	10·358806	9·687380	25 134	10·312620	10·046186	25 25	9·953814	10	30
58	52	9·641324	26 113	10·358676	9·687540	26 139	10·312460	10·046217	26 27	9·953783	8	2
30	54	9·641453	27 117	10·358547	9·687701	27 145	10·312299	10·046247	27 28	9·953753	6	30
59	56	9·641583	28 122	10·358417	9·687861	28 150	10·312139	10·046278	28 29	9·953722	4	1
30	58	9·641712	29 126	10·358288	9·688021	29 155	10·311979	10·046309	29 30	9·953691	2	30
60	44	9·641842	30 130	10·358158	9·688182	30 161	10·311818	10·046340	30 31	9·953660	0	0
′ ″	m. s	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s	′ ″

64° — 4h 16m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1ʰ 44ᵐ — 26°

′ ″	m.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m.	′ ″
0	0	9·641842		10·358158	9·688182		10·311818	10·046340		9·953660	26	60
30	2	9·641971	1″ 4	10·358029	9·688342	1″ 5	10·311658	10·046371	1″ 1	9·953629	58	30
1	4	9·642101	2 9	10·357899	9·688502	2 11	10·311498	10·046401	2 2	9·953599	56	59
30	6	9·642230	3 13	10·357770	9·688663	3 16	10·311337	10·046432	3 3	9·953568	54	30
2	8	9·642360	4 17	10·357640	9·688823	4 21	10·311177	10·046463	4 4	9·953537	52	58
30	10	9·642489	5 21	10·357511	9·688983	5 27	10·311017	10·046494	5 5	9·953506	50	30
3	12	9·642618	6 26	10·357382	9·689143	6 32	10·310857	10·046525	6 6	9·953475	48	57
30	14	9·642747	7 30	10·357253	9·689303	7 37	10·310697	10·046556	7 7	9·953444	46	30
4	16	9·642877	8 34	10·357123	9·689463	8 43	10·310537	10·046587	8 8	9·953413	44	56
30	18	9·643006	9 39	10·356994	9·689623	9 48	10·310377	10·046618	9 9	9·953382	42	30
5	20	9·643135	10 43	10·356865	9·689783	10 53	10·310217	10·046648	10 10	9·953352	40	55
30	22	9·643264	11 47	10·356736	9·689943	11 59	10·310057	10·046679	11 11	9·953321	38	30
6	24	9·643393	12 51	10·356607	9·690103	12 64	10·309897	10·046710	12 12	9·953290	36	54
30	26	9·643522	13 56	10·356478	9·690263	13 69	10·309737	10·046741	13 13	9·953259	34	30
7	28	9·643650	14 60	10·356350	9·690423	14 75	10·309577	10·046772	14 14	9·953228	32	53
30	30	9·643779	15 64	10·356221	9·690582	15 80	10·309418	10·046803	15 15	9·953197	30	30
8	32	9·643908	16 68	10·356092	9·690742	16 85	10·309258	10·046834	16 16	9·953166	28	52
30	34	9·644037	17 73	10·355963	9·690902	17 91	10·309098	10·046865	17 18	9·953135	26	30
9	36	9·644165	18 77	10·355835	9·691062	18 96	10·308938	10·046896	18 19	9·953104	24	51
30	38	9·644294	19 82	10·355706	9·691221	19 101	10·308779	10·046927	19 20	9·953073	22	30
10	40	9·644423	20 86	10·355577	9·691381	20 107	10·308619	10·046958	20 21	9·953042	20	50
30	42	9·644551	21 90	10·355449	9·691540	21 112	10·308460	10·046989	21 22	9·953011	18	30
11	44	9·644680	22 94	10·355320	9·691700	22 117	10·308300	10·047020	22 23	9·952980	16	49
30	46	9·644808	23 99	10·355192	9·691859	23 123	10·308141	10·047051	23 24	9·952949	14	30
12	48	9·644936	24 103	10·355064	9·692019	24 128	10·307981	10·047082	24 25	9·952918	12	48
30	50	9·645065	25 107	10·354935	9·692178	25 133	10·307822	10·047114	25 26	9·952886	10	30
13	52	9·645193	26 112	10·354807	9·692338	26 139	10·307662	10·047145	26 27	9·952855	8	47
30	54	9·645321	27 116	10·354679	9·692497	27 144	10·307503	10·047176	27 28	9·952824	6	30
14	56	9·645450	28 120	10·354550	9·692656	28 149	10·307344	10·047207	28 29	9·952793	4	46
30	58	9·645578	29 124	10·354422	9·692816	29 155	10·307184	10·047238	29 30	9·952762	2	30
15	45	9·645706	30 129	10·354294	9·692975	30 160	10·307025	10·047269	30 31	9·952731	15	45
30	2	9·645834	1 4	10·354166	9·693134	1 5	10·306866	10·047300	1 1	9·952700	58	30
16	4	9·645962	2 9	10·354038	9·693293	2 11	10·306707	10·047331	2 2	9·952669	56	44
30	6	9·646090	3 13	10·353910	9·693453	3 16	10·306547	10·047363	3 3	9·952637	54	30
17	8	9·646218	4 17	10·353782	9·693612	4 21	10·306388	10·047394	4 4	9·952606	52	43
30	10	9·646346	5 21	10·353654	9·693771	5 26	10·306229	10·047425	5 5	9·952575	50	30
18	12	9·646474	6 25	10·353526	9·693930	6 32	10·306070	10·047456	6 6	9·952544	48	42
30	14	9·646601	7 30	10·353399	9·694089	7 37	10·305911	10·047488	7 7	9·952512	46	30
19	16	9·646729	8 34	10·353271	9·694248	8 42	10·305752	10·047519	8 8	9·952481	44	41
30	18	9·646857	9 38	10·353143	9·694407	9 48	10·305593	10·047550	9 9	9·952450	42	30
20	20	9·646984	10 42	10·353016	9·694566	10 53	10·305434	10·047581	10 10	9·952419	40	40
30	22	9·647112	11 47	10·352888	9·694724	11 58	10·305276	10·047613	11 11	9·952387	38	30
21	24	9·647240	12 51	10·352760	9·694883	12 63	10·305117	10·047644	12 13	9·952356	36	39
30	26	9·647367	13 55	10·352633	9·695042	13 69	10·304958	10·047675	13 14	9·952325	34	30
22	28	9·647494	14 59	10·352506	9·695201	14 74	10·304799	10·047706	14 15	9·952294	32	38
30	30	9·647622	15 64	10·352378	9·695360	15 79	10·304640	10·047738	15 16	9·952262	30	30
23	32	9·647749	16 68	10·352251	9·695518	16 85	10·304482	10·047769	16 17	9·952231	28	37
30	34	9·647877	17 72	10·352123	9·695677	17 90	10·304323	10·047800	17 18	9·952200	26	30
24	36	9·648004	18 76	10·351996	9·695836	18 95	10·304164	10·047832	18 19	9·952168	24	36
30	38	9·648131	19 81	10·351869	9·695994	19 101	10·304006	10·047863	19 20	9·952137	22	30
25	40	9·648258	20 85	10·351742	9·696153	20 106	10·303847	10·047894	20 21	9·952106	20	35
30	42	9·648385	21 89	10·351615	9·696311	21 111	10·303689	10·047926	21 22	9·952074	18	30
26	44	9·648512	22 93	10·351488	9·696470	22 116	10·303530	10·047957	22 23	9·952043	16	34
30	46	9·648639	23 98	10·351361	9·696628	23 122	10·303372	10·047989	23 24	9·952011	14	30
27	48	9·648766	24 102	10·351234	9·696787	24 127	10·303213	10·048020	24 25	9·951980	12	33
30	50	9·648893	25 106	10·351107	9·696945	25 132	10·303055	10·048051	25 26	9·951949	10	30
28	52	9·649020	26 110	10·350980	9·697103	26 138	10·302897	10·048083	26 27	9·951917	8	32
30	54	9·649147	27 115	10·350853	9·697262	27 143	10·302739	10·048114	27 28	9·951886	6	30
29	56	9·649274	28 119	10·350726	9·697420	28 148	10·302580	10·048146	28 29	9·951854	4	31
30	58	9·649401	29 123	10·350599	9·697578	29 153	10·302422	10·048177	29 30	9·951823	2	30
30	46	9·649527	30 127	10·350473	9·697736	30 159	10·302264	10·048209	30 31	9·951791	0	30
′ ″	m.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m.	′ ″

63° — 4ʰ 14ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1ʰ 46ᵐ					26°							
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·649527		10·350473	9·697736		10·302264	10·048209		9·951791	14	30
30	2	9·649654	1″ 4	10·350346	9·697894	1″ 5	10·302106	10·048240	1″ 1	9·951760	58	30
31	4	9·649781	2 8	10·350219	9·698053	2 11	10·301947	10·048272	2 2	9·951728	56	29
30	6	9·649907	3 13	10·350093	9·698211	3 16	10·301789	10·048303	3 3	9·951697	54	30
32	8	9·650034	4 17	10·349966	9·698369	4 21	10·301631	10·048335	4 4	9·951665	52	28
30	10	9·650160	5 21	10·349840	9·698527	5 26	10·301473	10·048366	5 5	9·951634	50	30
33	12	9·650287	6 25	10·349713	9·698685	6 32	10·301315	10·048398	6 6	9·951602	48	27
30	14	9·650413	7 29	10·349587	9·698843	7 37	10·301157	10·048430	7 7	9·951570	46	30
34	16	9·650539	8 34	10·349461	9·699001	8 42	10·300999	10·048461	8 8	9·951539	44	26
30	18	9·650666	9 38	10·349334	9·699159	9 47	10·300841	10·048493	9 9	9·951507	42	30
35	20	9·650792	10 42	10·349208	9·699316	10 53	10·300684	10·048524	10 11	9·951476	40	25
30	22	9·650918	11 46	10·349082	9·699474	11 58	10·300526	10·048556	11 12	9·951444	38	30
36	24	9·651044	12 51	10·348956	9·699632	12 63	10·300368	10·048588	12 13	9·951412	36	24
30	26	9·651171	13 55	10·348829	9·699790	13 68	10·300210	10·048619	13 14	9·951381	34	30
37	28	9·651297	14 59	10·348703	9·699947	14 74	10·300053	10·048651	14 15	9·951349	32	23
30	30	9·651423	15 63	10·348577	9·700105	15 79	10·299895	10·048683	15 16	9·951317	30	30
38	32	9·651549	16 67	10·348451	9·700263	16 84	10·299737	10·048714	16 17	9·951286	28	22
30	34	9·651675	17 71	10·348325	9·700420	17 89	10·299580	10·048746	17 18	9·951254	26	30
39	36	9·651800	18 76	10·348200	9·700578	18 95	10·299422	10·048778	18 19	9·951222	24	21
30	38	9·651926	19 80	10·348074	9·700736	19 100	10·299264	10·048809	19 20	9·951191	22	30
40	40	9·652052	20 84	10·347948	9·700893	20 105	10·299107	10·048841	20 21	9·951159	20	20
30	42	9·652178	21 88	10·347822	9·701051	21 110	10·298949	10·048873	21 22	9·951127	18	30
41	44	9·652304	22 92	10·347696	9·701208	22 116	10·298792	10·048904	22 23	9·951096	16	19
30	46	9·652429	23 97	10·347571	9·701365	23 121	10·298635	10·048936	23 24	9·951064	14	30
42	48	9·652555	24 101	10·347445	9·701523	24 126	10·298477	10·048968	24 25	9·951032	12	18
30	50	9·652680	25 105	10·347320	9·701680	25 131	10·298320	10·049000	25 26	9·951000	10	30
43	52	9·652806	26 109	10·347194	9·701837	26 137	10·298163	10·049032	26 27	9·950968	8	17
30	54	9·652931	27 113	10·347069	9·701995	27 142	10·298005	10·049063	27 28	9·950937	6	30
44	56	9·653057	28 118	10·346943	9·702152	28 147	10·297848	10·049095	28 29	9·950905	4	16
30	58	9·653182	29 122	10·346818	9·702309	29 153	10·297691	10·049127	29 31	9·950873	2	30
45	47	9·653308	30 126	10·346692	9·702466	30 158	10·297534	10·049159	30 32	9·950841	13	15
30	2	9·653433	1 4	10·346567	9·702623	1 5	10·297377	10·049191	1 1	9·950809	58	30
46	4	9·653558	2 8	10·346442	9·702781	2 10	10·297219	10·049222	2 2	9·950778	56	14
30	6	9·653683	3 12	10·346317	9·702938	3 16	10·297062	10·049254	3 3	9·950746	54	30
47	8	9·653808	4 17	10·346192	9·703095	4 21	10·296905	10·049286	4 4	9·950714	52	13
30	10	9·653934	5 21	10·346066	9·703252	5 26	10·296748	10·049318	5 5	9·950682	50	30
48	12	9·654059	6 25	10·345941	9·703409	6 31	10·296591	10·049350	6 6	9·950650	48	12
30	14	9·654184	7 29	10·345816	9·703566	7 37	10·296434	10·049382	7 7	9·950618	46	30
49	16	9·654309	8 33	10·345691	9·703722	8 42	10·296278	10·049414	8 9	9·950586	44	11
30	18	9·654434	9 37	10·345566	9·703879	9 47	10·296121	10·049446	9 10	9·950554	42	30
50	20	9·654558	10 42	10·345442	9·704036	10 52	10·295964	10·049478	10 11	9·950522	40	10
30	22	9·654683	11 46	10·345317	9·704193	11 57	10·295807	10·049510	11 12	9·950490	38	30
51	24	9·654808	12 50	10·345192	9·704350	12 63	10·295650	10·049542	12 13	9·950458	36	9
30	26	9·654933	13 54	10·345067	9·704506	13 68	10·295494	10·049574	13 14	9·950426	34	30
52	28	9·655058	14 58	10·344942	9·704663	14 73	10·295337	10·049606	14 15	9·950394	32	8
30	30	9·655182	15 62	10·344818	9·704820	15 78	10·295180	10·049638	15 16	9·950362	30	30
53	32	9·655307	16 67	10·344693	9·704976	16 84	10·295024	10·049670	16 17	9·950330	28	7
30	34	9·655431	17 71	10·344569	9·705133	17 89	10·294867	10·049702	17 18	9·950298	26	30
54	36	9·655556	18 75	10·344444	9·705290	18 94	10·294710	10·049734	18 19	9·950266	24	6
30	38	9·655680	19 79	10·344320	9·705446	19 99	10·294554	10·049766	19 20	9·950234	22	30
55	40	9·655805	20 83	10·344195	9·705603	20 104	10·294397	10·049798	20 21	9·950202	20	5
30	42	9·655929	21 87	10·344071	9·705759	21 110	10·294241	10·049830	21 22	9·950170	18	30
56	44	9·656054	22 91	10·343946	9·705916	22 115	10·294084	10·049862	22 23	9·950138	16	4
30	46	9·656178	23 95	10·343822	9·706072	23 120	10·293928	10·049894	23 25	9·950106	14	30
57	48	9·656302	24 100	10·343698	9·706228	24 125	10·293772	10·049926	24 26	9·950074	12	3
30	50	9·656426	25 104	10·343574	9·706385	25 130	10·293615	10·049958	25 27	9·950042	10	30
58	52	9·656551	26 108	10·343449	9·706541	26 136	10·293459	10·049990	26 28	9·950010	8	2
30	54	9·656675	27 112	10·343325	9·706697	27 141	10·293303	10·050023	27 29	9·949977	6	30
59	56	9·656799	28 116	10·343201	9·706854	28 146	10·293146	10·050055	28 30	9·949945	4	1
30	58	9·656923	29 120	10·343077	9·707010	29 151	10·292990	10·050087	29 31	9·949913	2	30
60	48	9·657047	30 125	10·342953	9·707166	30 157	10·292834	10·050119	30 32	9·949881	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
					63°					4ʰ 12ᵐ		

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES. &c.

1^h 48^m						27°						
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·657047		10·342953	9·707166		10·292834	10·050119		9·949881	12	60
30	2	9·657171	1″ 4	10·342829	9·707322	1″ 5	10·292678	10·050151	1″ 1	9·949849	58	30
1	4	9·657295	2 8	10·342705	9·707478	2 10	10·292522	10·050184	2 2	9·949816	56	59
30	6	9·657418	3 12	10·342582	9·707634	3 16	10·292366	10·050216	3 3	9·949784	54	30
2	8	9·657542	4 16	10·342458	9·707790	4 21	10·292210	10·050248	4 4	9·949752	52	58
30	10	9·657666	5 21	10·342334	9·707946	5 26	10·292054	10·050280	5 5	9·949720	50	30
3	12	9·657790	6 25	10·342210	9·708102	6 31	10·291898	10·050312	6 6	9·949688	48	57
30	14	9·657913	7 29	10·342087	9·708258	7 36	10·291742	10·050345	7 8	9·949655	46	30
4	16	9·658037	8 33	10·341963	9·708414	8 42	10·291586	10·050377	8 9	9·949623	44	56
30	18	9·658161	9 37	10·341839	9·708570	9 47	10·291430	10·050409	9 10	9·949591	42	30
5	20	9·658284	10 41	10·341716	9·708726	10 52	10·291274	10·050442	10 11	9·949558	40	55
30	22	9·658408	11 45	10·341592	9·708882	11 57	10·291118	10·050474	11 12	9·949526	38	30
6	24	9·658531	12 49	10·341469	9·709037	12 62	10·290963	10·050506	12 13	9·949494	36	54
30	26	9·658655	13 53	10·341345	9·709193	13 67	10·290807	10·050538	13 14	9·949462	34	30
7	28	9·658778	14 57	10·341222	9·709349	14 73	10·290651	10·050571	14 15	9·949429	32	53
30	30	9·658901	15 62	10·341099	9·709504	15 78	10·290496	10·050603	15 16	9·949397	30	30
8	32	9·659025	16 66	10·340975	9·709660	16 83	10·290340	10·050636	16 17	9·949364	28	52
30	34	9·659148	17 70	10·340852	9·709816	17 88	10·290184	10·050668	17 18	9·949332	26	30
9	36	9·659271	18 74	10·340729	9·709971	18 93	10·290029	10·050700	18 19	9·949300	24	51
30	38	9·659394	19 78	10·340606	9·710127	19 99	10·289873	10·050733	19 21	9·949267	22	30
10	40	9·659517	20 82	10·340483	9·710282	20 104	10·289718	10·050765	20 22	9·949235	20	50
30	42	9·659640	21 86	10·340360	9·710438	21 109	10·289562	10·050798	21 23	9·949202	18	30
11	44	9·659763	22 90	10·340237	9·710593	22 114	10·289407	10·050830	22 24	9·949170	16	49
30	46	9·659886	23 95	10·340114	9·710749	23 119	10·289251	10·050862	23 25	9·949138	14	30
12	48	9·660009	24 99	10·339991	9·710904	24 125	10·289096	10·050895	24 26	9·949105	12	48
30	50	9·660132	25 103	10·339868	9·711059	25 130	10·288941	10·050927	25 27	9·949073	10	30
13	52	9·660255	26 107	10·339745	9·711215	26 135	10·288785	10·050960	26 28	9·949040	8	47
30	54	9·660378	27 111	10·339622	9·711370	27 140	10·288630	10·050992	27 29	9·949008	6	30
14	56	9·660501	28 115	10·339499	9·711525	28 145	10·288475	10·051025	28 30	9·948975	4	46
30	58	9·660623	29 119	10·339377	9·711681	29 151	10·288319	10·051057	29 31	9·948943	2	30
15	60	9·660746	30 123	10·339254	9·711836	30 156	10·288164	10·051090	30 32	9·948910	11	45
30	2	9·660869	1 4	10·339131	9·711991	1 5	10·288009	10·051122	1 1	9·948878	58	30
16	4	9·660991	2 8	10·339009	9·712146	2 10	10·287854	10·051155	2 2	9·948845	56	44
30	6	9·661114	3 12	10·338886	9·712301	3 15	10·287699	10·051188	3 3	9·948812	54	30
17	8	9·661236	4 16	10·338764	9·712456	4 21	10·287544	10·051220	4 4	9·948780	52	43
30	10	9·661359	5 20	10·338641	9·712611	5 26	10·287389	10·051253	5 5	9·948747	50	30
18	12	9·661481	6 24	10·338519	9·712766	6 31	10·287234	10·051285	6 7	9·948715	48	42
30	14	9·661603	7 28	10·338397	9·712921	7 36	10·287079	10·051318	7 8	9·948682	46	30
19	16	9·661726	8 33	10·338274	9·713076	8 41	10·286924	10·051350	8 9	9·948650	44	41
30	18	9·661848	9 37	10·338152	9·713231	9 46	10·286769	10·051383	9 10	9·948617	42	30
20	20	9·661970	10 41	10·338030	9·713386	10 52	10·286614	10·051416	10 11	9·948584	40	40
30	22	9·662092	11 45	10·337908	9·713541	11 57	10·286459	10·051448	11 12	9·948552	38	30
21	24	9·662214	12 49	10·337786	9·713696	12 62	10·286304	10·051481	12 13	9·948519	36	39
30	26	9·662337	13 53	10·337663	9·713850	13 67	10·286150	10·051514	13 14	9·948486	34	30
22	28	9·662459	14 57	10·337541	9·714005	14 72	10·285995	10·051546	14 15	9·948454	32	38
30	30	9·662581	15 61	10·337419	9·714160	15 77	10·285840	10·051579	15 16	9·948421	30	30
23	32	9·662703	16 65	10·337297	9·714314	16 83	10·285686	10·051612	16 17	9·948388	28	37
30	34	9·662825	17 69	10·337175	9·714469	17 88	10·285531	10·051645	17 18	9·948355	26	30
24	36	9·662946	18 73	10·337054	9·714624	18 93	10·285376	10·051677	18 19	9·948323	24	36
30	38	9·663068	19 77	10·336932	9·714778	19 98	10·285222	10·051710	19 21	9·948290	22	30
25	40	9·663190	20 81	10·336810	9·714933	20 103	10·285067	10·051743	20 22	9·948257	20	35
30	42	9·663312	21 85	10·336688	9·715087	21 108	10·284913	10·051776	21 23	9·948224	18	30
26	44	9·663433	22 89	10·336567	9·715242	22 114	10·284758	10·051808	22 24	9·948192	16	34
30	46	9·663555	23 94	10·336445	9·715396	23 119	10·284604	10·051841	23 25	9·948159	14	30
27	48	9·663677	24 98	10·336323	9·715551	24 124	10·284449	10·051874	24 26	9·948126	12	33
30	50	9·663798	25 102	10·336202	9·715705	25 129	10·284295	10·051907	25 27	9·948093	10	30
28	52	9·663920	26 106	10·336080	9·715860	26 134	10·284140	10·051940	26 28	9·948060	8	32
30	54	9·664041	27 110	10·335959	9·716014	27 139	10·283986	10·051972	27 29	9·948028	6	30
29	56	9·664163	28 114	10·335837	9·716168	28 144	10·283832	10·052005	28 31	9·947995	4	31
30	58	9·664284	29 118	10·335716	9·716322	29 150	10·283678	10·052038	29 32	9·947962	2	30
30	60	9·664406	30 122	10·335594	9·716477	30 155	10·283523	10·052071	30 33	9·947929	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
						62°					4^h 10^m	

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1h 50m					27°							
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·664406		10·335594	9·716477		10·283523	10·052071		9·947929	10	30
30	2	9·664527	1″ 4	10·335473	9·716631	1″ 5	10·283369	10·052104	1″ 1	9·947896	58	30
31	4	9·664648	2 8	10·335352	9·716785	2 10	10·283215	10·052137	2 2	9·947863	56	29
30	6	9·664769	3 12	10·335231	9·716939	3 15	10·283061	10·052170	3 3	9·947830	54	30
32	8	9·664891	4 16	10·335109	9·717093	4 20	10·282907	10·052203	4 4	9·947797	52	28
30	10	9·665012	5 20	10·334988	9·717247	5 26	10·282753	10·052236	5 5	9·947764	50	30
33	12	9·665133	6 24	10·334867	9·717401	6 31	10·282599	10·052269	6 7	9·947731	48	27
30	14	9·665254	7 28	10·334746	9·717555	7 36	10·282445	10·052302	7 8	9·947698	46	30
34	16	9·665375	8 32	10·334625	9·717709	8 41	10·282291	10·052335	8 9	9·947665	44	26
30	18	9·665496	9 36	10·334504	9·717863	9 46	10·282137	10·052367	9 10	9·947633	42	30
35	20	9·665617	10 40	10·334383	9·718017	10 51	10·281983	10·052400	10 11	9·947600	40	25
30	22	9·665738	11 44	10·334262	9·718171	11 56	10·281829	10·052433	11 12	9·947567	38	30
36	24	9·665859	12 48	10·334141	9·718325	12 61	10·281675	10·052467	12 13	9·947533	36	24
30	26	9·665979	13 52	10·334021	9·718479	13 67	10·281521	10·052500	13 14	9·947500	34	30
37	28	9·666100	14 56	10·333900	9·718633	14 72	10·281367	10·052533	14 15	9·947467	32	23
30	30	9·666221	15 60	10·333779	9·718786	15 77	10·281214	10·052566	15 16	9·947434	30	30
38	32	9·666342	16 64	10·333658	9·718940	16 82	10·281060	10·052599	16 18	9·947401	28	22
30	34	9·666462	17 68	10·333538	9·719094	17 87	10·280906	10·052632	17 19	9·947368	26	30
39	36	9·666583	18 72	10·333417	9·719248	18 92	10·280752	10·052665	18 20	9·947335	24	21
30	38	9·666703	19 76	10·333297	9·719401	19 97	10·280599	10·052698	19 21	9·947302	22	30
40	40	9·666824	20 80	10·333176	9·719555	20 102	10·280445	10·052731	20 22	9·947269	20	20
30	42	9·666944	21 84	10·333056	9·719708	21 108	10·280292	10·052764	21 23	9·947236	18	30
41	44	9·667065	22 88	10·332935	9·719862	22 113	10·280138	10·052797	22 24	9·947203	16	19
30	46	9·667185	23 92	10·332815	9·720016	23 118	10·279984	10·052830	23 25	9·947170	14	30
42	48	9·667305	24 96	10·332695	9·720169	24 123	10·279831	10·052864	24 26	9·947136	12	18
30	50	9·667426	25 101	10·332574	9·720322	25 128	10·279678	10·052897	25 28	9·947103	10	30
43	52	9·667546	26 105	10·332454	9·720476	26 133	10·279524	10·052930	26 29	9·947070	8	17
30	54	9·667666	27 109	10·332334	9·720629	27 138	10·279371	10·052963	27 30	9·947037	6	30
44	56	9·667786	28 113	10·332214	9·720783	28 143	10·279217	10·052996	28 31	9·947004	4	16
30	58	9·667906	29 117	10·332094	9·720936	29 148	10·279064	10·053030	29 32	9·946970	2	30
45	51	9·668027	30 121	10·331973	9·721089	30 154	10·278911	10·053063	30 33	9·946937	9	15
30	2	9·668147	1 4	10·331853	9·721243	1 5	10·278757	10·053096	1 1	9·946904	58	30
46	4	9·668267	2 8	10·331733	9·721396	2 10	10·278604	10·053129	2 2	9·946871	56	14
30	6	9·668386	3 12	10·331614	9·721549	3 15	10·278451	10·053163	3 3	9·946837	54	30
47	8	9·668506	4 16	10·331494	9·721702	4 20	10·278298	10·053196	4 4	9·946804	52	13
30	10	9·668626	5 20	10·331374	9·721855	5 25	10·278145	10·053229	5 6	9·946771	50	30
48	12	9·668746	6 24	10·331254	9·722009	6 30	10·277991	10·053262	6 7	9·946738	48	12
30	14	9·668866	7 28	10·331134	9·722162	7 36	10·277838	10·053296	7 8	9·946704	46	30
49	16	9·668986	8 32	10·331014	9·722315	8 41	10·277685	10·053329	8 9	9·946671	44	11
30	18	9·669105	9 36	10·330895	9·722468	9 46	10·277532	10·053362	9 10	9·946638	42	30
50	20	9·669225	10 40	10·330775	9·722621	10 51	10·277379	10·053396	10 11	9·946604	40	10
30	22	9·669345	11 44	10·330655	9·722774	11 56	10·277226	10·053429	11 12	9·946571	38	30
51	24	9·669464	12 48	10·330536	9·722927	12 61	10·277073	10·053462	12 13	9·946538	36	9
30	26	9·669584	13 52	10·330416	9·723080	13 66	10·276920	10·053496	13 14	9·946504	34	30
52	28	9·669703	14 56	10·330297	9·723232	14 71	10·276768	10·053529	14 16	9·946471	32	8
30	30	9·669823	15 60	10·330177	9·723385	15 76	10·276615	10·053563	15 17	9·946437	30	30
53	32	9·669942	16 64	10·330058	9·723538	16 81	10·276462	10·053596	16 18	9·946404	28	7
30	34	9·670061	17 68	10·329939	9·723691	17 87	10·276309	10·053629	17 19	9·946371	26	30
54	36	9·670181	18 72	10·329819	9·723844	18 92	10·276156	10·053663	18 20	9·946337	24	6
30	38	9·670300	19 76	10·329700	9·723996	19 97	10·276004	10·053696	19 21	9·946304	22	30
55	40	9·670419	20 80	10·329581	9·724149	20 102	10·275851	10·053730	20 22	9·946270	20	5
30	42	9·670538	21 84	10·329462	9·724302	21 107	10·275698	10·053763	21 23	9·946237	18	30
56	44	9·670658	22 88	10·329342	9·724454	22 112	10·275546	10·053797	22 24	9·946203	16	4
30	46	9·670777	23 92	10·329223	9·724607	23 117	10·275393	10·053830	23 26	9·946170	14	30
57	48	9·670896	24 96	10·329104	9·724760	24 122	10·275240	10·053864	24 27	9·946136	12	3
30	50	9·671015	25 100	10·328985	9·724912	25 127	10·275088	10·053897	25 28	9·946103	10	30
58	52	9·671134	26 104	10·328866	9·725065	26 132	10·274935	10·053931	26 29	9·946069	8	2
30	54	9·671253	27 107	10·328747	9·725217	27 137	10·274783	10·053964	27 30	9·946036	6	30
59	56	9·671372	28 111	10·328628	9·725370	28 143	10·274630	10·053998	28 31	9·946002	4	1
30	58	9·671490	29 115	10·328510	9·725522	29 148	10·274478	10·054031	29 32	9·945969	2	30
60	52	9·671609	30 119	10·328391	9·725674	30 153	10·274326	10·054065	30 33	9·945935	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
					62°						4h 8m	

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1ʰ 52ᵐ — 28°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·671609		10·328391	9·725674		10·274326	10·054065		9·945935	8	60
30	2	9·671728	1″ 4	10·328272	9·725827	1″ 5	10·274173	10·054099	1″ 1	9·945901	58	30
1	4	9·671847	2 8	10·328153	9·725979	2 10	10·274021	10·054132	2 2	9·945868	56	59
30	6	9·671965	3 12	10·328035	9·726131	3 15	10·273869	10·054166	3 3	9·945834	54	30
2	8	9·672084	4 16	10·327916	9·726284	4 20	10·273716	10·054200	4 4	9·945800	52	58
30	10	9·672203	5 20	10·327797	9·726436	5 25	10·273564	10·054233	5 6	9·945767	50	30
3	12	9·672321	6 24	10·327679	9·726588	6 30	10·273412	10·054267	6 7	9·945733	48	57
30	14	9·672440	7 28	10·327560	9·726740	7 35	10·273260	10·054300	7 8	9·945700	46	30
4	16	9·672558	8 32	10·327442	9·726892	8 40	10·273108	10·054334	8 9	9·945666	44	56
30	18	9·672677	9 35	10·327323	9·727045	9 46	10·272955	10·054368	9 10	9·945632	42	30
5	20	9·672795	10 39	10·327205	9·727197	10 51	10·272803	10·054402	10 11	9·945598	40	55
30	22	9·672914	11 43	10·327086	9·727349	11 56	10·272651	10·054435	11 12	9·945565	38	30
6	24	9·673032	12 47	10·326968	9·727501	12 61	10·272499	10·054469	12 13	9·945531	36	54
30	26	9·673150	13 51	10·326850	9·727653	13 66	10·272347	10·054503	13 15	9·945497	34	30
7	28	9·673268	14 55	10·326732	9·727805	14 71	10·272195	10·054536	14 16	9·945464	32	53
30	30	9·673387	15 59	10·326613	9·727957	15 76	10·272043	10·054570	15 17	9·945430	30	30
8	32	9·673505	16 63	10·326495	9·728109	16 81	10·271891	10·054604	16 18	9·945396	28	52
30	34	9·673623	17 67	10·326377	9·728261	17 86	10·271739	10·054638	17 19	9·945362	26	30
9	36	9·673741	18 71	10·326259	9·728412	18 91	10·271588	10·054672	18 20	9·945328	24	51
30	38	9·673859	19 75	10·326141	9·728564	19 96	10·271436	10·054705	19 21	9·945295	22	30
10	40	9·673977	20 79	10·326023	9·728716	20 101	10·271284	10·054739	20 23	9·945261	20	50
30	42	9·674095	21 83	10·325905	9·728868	21 106	10·271132	10·054773	21 24	9·945227	18	30
11	44	9·674213	22 87	10·325787	9·729020	22 111	10·270980	10·054807	22 25	9·945193	16	49
30	46	9·674331	23 91	10·325669	9·729171	23 116	10·270829	10·054841	23 26	9·945159	14	30
12	48	9·674448	24 95	10·325552	9·729323	24 121	10·270677	10·054875	24 27	9·945125	12	48
30	50	9·674566	25 99	10·325434	9·729475	25 126	10·270525	10·054908	25 28	9·945092	10	30
13	52	9·674684	26 103	10·325316	9·729626	26 132	10·270374	10·054942	26 29	9·945058	8	47
30	54	9·674802	27 106	10·325198	9·729778	27 137	10·270222	10·054976	27 30	9·945024	6	30
14	56	9·674919	28 110	10·325081	9·729929	28 142	10·270071	10·055010	28 31	9·944990	4	46
30	58	9·675037	29 114	10·324963	9·730081	29 147	10·269919	10·055044	29 32	9·944956	2	30
15	53	9·675155	30 118	10·324845	9·730233	30 152	10·269767	10·055078	30 34	9·944922	7	45
30	2	9·675272	1 4	10·324728	9·730384	1 5	10·269616	10·055112	1 1	9·944888	58	30
16	4	9·675390	2 8	10·324610	9·730535	2 10	10·269465	10·055146	2 2	9·944854	56	44
30	6	9·675507	3 12	10·324493	9·730687	3 15	10·269313	10·055180	3 3	9·944820	54	30
17	8	9·675624	4 16	10·324376	9·730838	4 20	10·269162	10·055214	4 5	9·944786	52	43
30	10	9·675742	5 19	10·324258	9·730990	5 25	10·269010	10·055248	5 6	9·944752	50	30
18	12	9·675859	6 23	10·324141	9·731141	6 30	10·268859	10·055282	6 7	9·944718	48	42
30	14	9·675976	7 27	10·324024	9·731292	7 35	10·268708	10·055316	7 8	9·944684	46	30
19	16	9·676094	8 31	10·323906	9·731444	8 40	10·268556	10·055350	8 9	9·944650	44	41
30	18	9·676211	9 35	10·323789	9·731595	9 45	10·268405	10·055384	9 10	9·944616	42	30
20	20	9·676328	10 39	10·323672	9·731746	10 50	10·268254	10·055418	10 11	9·944582	40	40
30	22	9·676445	11 43	10·323555	9·731897	11 55	10·268103	10·055452	11 12	9·944548	38	30
21	24	9·676562	12 47	10·323438	9·732048	12 60	10·267952	10·055486	12 14	9·944514	36	39
30	26	9·676679	13 51	10·323321	9·732200	13 65	10·267800	10·055520	13 15	9·944480	34	30
22	28	9·676796	14 55	10·323204	9·732351	14 70	10·267649	10·055554	14 16	9·944446	32	38
30	30	9·676913	15 58	10·323087	9·732502	15 75	10·267498	10·055588	15 17	9·944412	30	30
23	32	9·677030	16 62	10·322970	9·732653	16 80	10·267347	10·055623	16 18	9·944377	28	37
30	34	9·677147	17 66	10·322853	9·732804	17 86	10·267196	10·055657	17 19	9·944343	26	30
24	36	9·677264	18 70	10·322736	9·732955	18 91	10·267045	10·055691	18 20	9·944309	24	36
30	38	9·677381	19 74	10·322619	9·733106	19 96	10·266894	10·055725	19 21	9·944275	22	30
25	40	9·677498	20 78	10·322502	9·733257	20 101	10·266743	10·055759	20 23	9·944241	20	35
30	42	9·677614	21 82	10·322386	9·733408	21 106	10·266592	10·055793	21 24	9·944207	18	30
26	44	9·677731	22 86	10·322269	9·733558	22 111	10·266442	10·055828	22 25	9·944172	16	34
30	46	9·677848	23 89	10·322152	9·733709	23 116	10·266291	10·055862	23 26	9·944138	14	30
27	48	9·677964	24 93	10·322036	9·733860	24 121	10·266140	10·055896	24 27	9·944104	12	33
30	50	9·678081	25 97	10·321919	9·734011	25 126	10·265989	10·055930	25 28	9·944070	10	30
28	52	9·678197	26 101	10·321803	9·734162	26 131	10·265838	10·055964	26 29	9·944036	8	32
30	54	9·678314	27 105	10·321686	9·734312	27 136	10·265688	10·055999	27 31	9·944001	6	30
29	56	9·678430	28 109	10·321570	9·734463	28 141	10·265537	10·056033	28 32	9·943967	4	31
30	58	9·678547	29 113	10·321453	9·734614	29 146	10·265386	10·056067	29 33	9·943933	2	30
30	54	9·678663	30 117	10·321337	9·734764	30 151	10·265236	10·056101	30 34	9·943899	6	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

61° — 4ʰ 6ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

$1^h\ 54^m$ — 28°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·678663		10·321337	9·734764		10·265236	10·056101		9·943899	6	30
30	2	9·678779	1″ 4	10·321221	9·734915	1″ 5	10·265085	10·056136	1″ 1	9·943864	58	30
31	4	9·678895	2 8	10·321105	9·735066	2 10	10·264934	10·056170	2 2	9·943830	56	29
30	6	9·679012	3 12	10·320988	9·735216	3 15	10·264784	10·056204	3 3	9·943796	54	30
32	8	9·679128	4 15	10·320872	9·735367	4 20	10·264633	10·056239	4 5	9·943761	52	28
30	10	9·679244	5 19	10·320756	9·735517	5 25	10·264483	10·056273	5 6	9·943727	50	30
33	12	9·679360	6 23	10·320640	9·735668	6 30	10·264332	10·056307	6 7	9·943693	48	27
30	14	9·679476	7 27	10·320524	9·735818	7 35	10·264182	10·056342	7 8	9·943658	46	30
34	16	9·679592	8 31	10·320408	9·735969	8 40	10·264031	10·056376	8 9	9·943624	44	26
30	18	9·679708	9 35	10·320292	9·736119	9 45	10·263881	10·056411	9 10	9·943589	42	30
35	20	9·679824	10 39	10·320176	9·736269	10 50	10·263731	10·056445	10 11	9·943555	40	25
30	22	9·679940	11 42	10·320060	9·736420	11 55	10·263580	10·056479	11 13	9·943521	38	30
36	24	9·680056	12 46	10·319944	9·736570	12 60	10·263430	10·056514	12 14	9·943486	36	24
30	26	9·680172	13 50	10·319828	9·736720	13 65	10·263280	10·056548	13 15	9·943452	34	30
37	28	9·680288	14 54	10·319712	9·736870	14 70	10·263130	10·056583	14 16	9·943417	32	23
30	30	9·680403	15 58	10·319597	9·737021	15 75	10·262979	10·056617	15 17	9·943383	30	30
38	32	9·680519	16 62	10·319481	9·737171	16 80	10·262829	10·056652	16 18	9·943348	28	22
30	34	9·680635	17 66	10·319365	9·737321	17 85	10·262679	10·056686	17 20	9·943314	26	30
39	36	9·680750	18 69	10·319250	9·737471	18 90	10·262529	10·056721	18 21	9·943279	24	21
30	38	9·680866	19 73	10·319134	9·737621	19 95	10·262379	10·056755	19 22	9·943245	22	30
40	40	9·680982	20 77	10·319018	9·737771	20 100	10·262229	10·056790	20 23	9·943210	20	20
30	42	9·681097	21 81	10·318903	9·737921	21 105	10·262079	10·056824	21 24	9·943176	18	30
41	44	9·681213	22 85	10·318787	9·738071	22 110	10·261929	10·056859	22 25	9·943141	16	19
30	46	9·681328	23 89	10·318672	9·738221	23 115	10·261779	10·056893	23 26	9·943107	14	30
42	48	9·681443	24 93	10·318557	9·738371	24 120	10·261629	10·056928	24 28	9·943072	12	18
30	50	9·681559	25 97	10·318441	9·738521	25 125	10·261479	10·056963	25 29	9·943037	10	30
43	52	9·681674	26 100	10·318326	9·738671	26 130	10·261329	10·056997	26 30	9·943003	8	17
30	54	9·681789	27 104	10·318211	9·738821	27 135	10·261179	10·057032	27 31	9·942968	6	30
44	56	9·681905	28 108	10·318095	9·738971	28 140	10·261029	10·057066	28 32	9·942934	4	16
30	58	9·682020	29 112	10·317980	9·739121	29 145	10·260879	10·057101	29 33	9·942899	2	30
45	55	9·682135	30 116	10·317865	9·739271	30 150	10·260729	10·057136	30 34	9·942864	5	15
30	2	9·682250	1 4	10·317750	9·739420	1 5	10·260580	10·057170	1 1	9·942830	58	30
46	4	9·682365	2 8	10·317635	9·739570	2 10	10·260430	10·057205	2 2	9·942795	56	14
30	6	9·682480	3 11	10·317520	9·739720	3 15	10·260280	10·057240	3 3	9·942760	54	30
47	8	9·682595	4 15	10·317405	9·739870	4 20	10·260130	10·057274	4 5	9·942726	52	13
30	10	9·682710	5 19	10·317290	9·740019	5 25	10·259981	10·057309	5 6	9·942691	50	30
48	12	9·682825	6 23	10·317175	9·740169	6 30	10·259831	10·057344	6 7	9·942656	48	12
30	14	9·682940	7 27	10·317060	9·740319	7 35	10·259681	10·057379	7 8	9·942621	46	30
49	16	9·683055	8 31	10·316945	9·740468	8 40	10·259532	10·057413	8 9	9·942587	44	11
30	18	9·683170	9 34	10·316830	9·740618	9 45	10·259382	10·057448	9 10	9·942552	42	30
50	20	9·683284	10 38	10·316716	9·740767	10 50	10·259233	10·057483	10 11	9·942517	40	10
30	22	9·683399	11 42	10·316601	9·740917	11 55	10·259083	10·057518	11 13	9·942482	38	30
51	24	9·683514	12 46	10·316486	9·741066	12 60	10·258934	10·057552	12 14	9·942448	36	9
30	26	9·683628	13 50	10·316372	9·741216	13 65	10·258784	10·057587	13 15	9·942413	34	30
52	28	9·683743	14 54	10·316257	9·741365	14 70	10·258635	10·057622	14 16	9·942378	32	8
30	30	9·683858	15 57	10·316142	9·741514	15 75	10·258486	10·057657	15 17	9·942343	30	30
53	32	9·683972	16 61	10·316028	9·741664	16 80	10·258336	10·057692	16 19	9·942308	28	7
30	34	9·684087	17 65	10·315913	9·741813	17 85	10·258187	10·057727	17 20	9·942273	26	30
54	36	9·684201	18 69	10·315799	9·741962	18 90	10·258038	10·057761	18 21	9·942239	24	6
30	38	9·684315	19 73	10·315685	9·742112	19 95	10·257888	10·057796	19 22	9·942204	22	30
55	40	9·684430	20 76	10·315570	9·742261	20 100	10·257739	10·057831	20 23	9·942169	20	5
30	42	9·684544	21 80	10·315456	9·742410	21 105	10·257590	10·057866	21 24	9·942134	18	30
56	44	9·684658	22 84	10·315342	9·742559	22 110	10·257441	10·057901	22 26	9·942099	16	4
30	46	9·684773	23 88	10·315227	9·742709	23 115	10·257291	10·057936	23 27	9·942064	14	30
57	48	9·684887	24 92	10·315113	9·742858	24 120	10·257142	10·057971	24 28	9·942029	12	3
30	50	9·685001	25 96	10·314999	9·743007	25 124	10·256993	10·058006	25 29	9·941994	10	30
58	52	9·685115	26 100	10·314885	9·743156	26 129	10·256844	10·058041	26 30	9·941959	8	2
30	54	9·685229	27 103	10·314771	9·743305	27 134	10·256695	10·058076	27 31	9·941924	6	30
59	56	9·685343	28 107	10·314657	9·743454	28 139	10·256546	10·058111	28 32	9·941889	4	1
30	58	9·685457	29 111	10·314543	9·743603	29 144	10·256397	10·058146	29 34	9·941854	2	30
60	56	9·685571	30 115	10·314429	9·743752	30 149	10·256248	10·058181	30 35	9·941819	4	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

61° — $4^h\ 4^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

1h 56m — 29°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·685571		10·314429	9·743752		10·256248	10·058181		9·941819	4	60
30	2	9·685685	1″ 4	10·314315	9·743901	1″ 5	10·256099	10·058216	1″ 1	9·941784	58	30
1	4	9·685799	2 8	10·314201	9·744050	2 10	10·255950	10·058251	2 2	9·941749	56	59
30	6	9·685913	3 11	10·314087	9·744199	3 15	10 255801	10·058286	3 4	9·941714	54	30
2	8	9·686027	4 15	10·313973	9·744348	4 20	10·255652	10·058321	4 5	9·941679	52	58
30	10	9·686141	5 19	10·313859	9·744496	5 25	10·255504	10·058356	5 6	9·941644	50	30
3	12	9·686254	6 23	10·313746	9·744645	6 30	10·255355	10·058391	6 7	9·941609	48	57
30	14	9·686368	7 26	10·313632	9·744794	7 35	10·255206	10·058426	7 8	9·941574	46	30
4	16	9·686482	8 30	10·313518	9·744943	8 40	10·255057	10·058461	8 9	9·941539	44	56
30	18	9·686595	9 34	10·313405	9·745092	9 45	10·254908	10·058496	9 11	9·941504	42	30
5	20	9·686709	10 38	10·313291	9·745240	10 49	10·254760	10·058531	10 12	9·941469	40	55
30	22	9·686822	11 42	10·313178	9·745389	11 54	10·254611	10·058567	11 13	9·941433	38	30
6	24	9·686936	12 46	10·313064	9·745538	12 59	10·254462	10·058602	12 14	9·941398	36	54
30	26	9·687049	13 49	10·312951	9·745686	13 64	10·254314	10·058637	13 15	9·941363	34	30
7	28	9·687163	14 53	10·312837	9·745835	14 69	10·254165	10·058672	14 16	9·941328	32	53
30	30	9·687276	15 57	10·312724	9·745983	15 74	10·254017	10·058707	15 18	9·941293	30	30
8	32	9·687389	16 61	10·312611	9·746132	16 79	10·253868	10·058742	16 19	9·941258	28	52
30	34	9·687503	17 64	10·312497	9·746281	17 84	10·253719	10·058778	17 20	9·941222	20	30
9	36	9·687616	18 68	10·312384	9·746429	18 89	10·253571	10·058813	18 21	9·941187	24	51
30	38	9·687729	19 72	10·312271	9·746577	19 94	10·253423	10·058848	19 22	9·941152	22	30
10	40	9·687843	20 76	10·312157	9·746726	20 99	10·253274	10·058883	20 23	9·941117	20	50
30	42	9·687956	21 79	10·312044	9·746874	21 104	10·253126	10·058919	21 25	9·941081	18	30
11	44	9·688069	22 83	10·311931	9·747023	22 109	10·252977	10·058954	22 26	9·941046	16	49
30	46	9·688182	23 87	10·311818	9·747171	23 114	10·252829	10·058989	23 27	9·941011	14	30
12	48	9·688295	24 91	10·311705	9·747319	24 119	10·252681	10·059025	24 28	9·940975	12	48
3	50	9·688408	25 95	10·311592	9·747468	25 124	10·252532	10·059060	25 29	9·940940	10	30
13	52	9·688521	26 98	10·311479	9·747616	26 129	10·252384	10·059095	26 30	9·940905	8	47
30	54	9·688634	27 102	10·311366	9·747764	27 134	10·252236	10·059130	27 32	9·940870	6	30
14	56	9·688747	28 106	10·311253	9·747913	28 139	10·252087	10·059166	28 33	9·940834	4	46
30	58	9·688860	29 110	10·311140	9·748061	29 144	10·251939	10·059201	29 34	9·940799	2	30
15	57	9·688972	30 113	10·311028	9·748209	30 148	10·251791	10·059237	30 35	9·940763	3	45
30	2	9·689085	1 4	10·310915	9·748357	1 5	10·251643	10·059272	1 1	9·940728	58	30
16	4	9·689198	2 7	10·310802	9·748505	2 10	10·251495	10·059307	2 2	9·940693	56	44
30	6	9·689311	3 11	10·310689	9·748653	3 15	10·251347	10·059343	3 4	9·940657	54	30
17	8	9·689423	4 15	10·310577	9·748801	4 20	10·251199	10·059378	4 5	9·940622	52	43
30	10	9·689536	5 19	10·310464	9·748949	5 25	10·251051	10·059414	5 6	9·940586	50	30
18	12	9·689648	6 22	10·310352	9·749097	6 30	10·250903	10·059449	6 7	9·940551	48	42
30	14	9·689761	7 26	10·310239	9·749245	7 34	10·250755	10·059484	7 8	9·940516	46	30
19	16	9·689873	8 30	10·310127	9·749393	8 39	10·250607	10·059520	8 9	9·940480	44	41
30	18	9·689986	9 34	10·310014	9·749541	9 44	10·250459	10·059555	9 11	9·940445	42	30
20	20	9·690098	10 37	10·309902	9·749689	10 49	10·250311	10·059591	10 12	9·940409	40	40
30	22	9·690211	11 41	10·309789	9·749837	11 54	10·250163	10·059626	11 13	9·940374	38	30
21	24	9·690323	12 45	10·309677	9·749985	12 59	10·250015	10·059662	12 14	9·940338	36	39
30	26	9·690435	13 49	10·309565	9·750133	13 64	10·249867	10·059697	13 15	9·940303	34	30
22	28	9·690548	14 52	10·309452	9·750281	14 69	10·249719	10·059733	14 17	9·940267	32	38
30	30	9·690660	15 56	10·309340	9·750428	15 74	10·249572	10·059769	15 18	9·940231	30	30
23	32	9·690772	16 60	10·309228	9·750576	16 79	10·249424	10·059804	16 19	9·940196	28	37
30	34	9·690884	17 64	10·309116	9·750724	17 84	10·249276	10·059840	17 20	9·940160	28	30
24	36	9·690996	18 67	10·309004	9·750872	18 89	10·249128	10·059875	18 21	9·940125	24	36
30	38	9·691108	19 71	10·308892	9·751019	19 93	10·248981	10·059911	19 22	9·940089	22	30
25	40	9·691220	20 75	10·308780	9·751167	20 98	10·248833	10·059946	20 24	9·940054	20	35
30	42	9·691332	21 79	10·308668	9·751315	21 103	10·248685	10·059982	21 25	9·940018	18	30
26	44	9·691444	22 82	10·308556	9·751462	22 108	10·248538	10·060018	22 26	9·939982	16	34
30	46	9·691556	23 86	10·308444	9·751610	23 113	10·248390	10·060053	23 27	9·939947	14	30
27	48	9·691668	24 90	10·308332	9·751757	24 118	10·248243	10·060089	24 28	9·939911	12	33
30	50	9·691780	25 94	10·308220	9·751905	25 123	10·248095	10·060125	25 30	9·939875	10	30
28	52	9·691892	26 98	10·308108	9·752052	26 128	10·247948	10·060160	26 31	9·939840	8	32
30	54	9·692004	27 101	10·307996	9·752200	27 133	10·247800	10·060196	27 32	9·939804	6	30
29	56	9·692115	28 105	10·307885	9·752347	28 138	10·247653	10·060232	28 33	9·939768	4	31
30	58	9·692227	29 108	10·307773	9·752495	29 143	10·247505	10·060267	29 34	9·939733	2	30
30	58	9·692339	30 112	10·307661	9·752642	30 148	10·247358	10·060303	30 36	9·939697	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

60° — 4h 2m

TABLE XXXVII.—(*continued*).

LOG. SINES. COSINES. &c.

1h 58m — 29°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·692339		10·307661	9·752642		10·247358	10·060303		9·939697	2	30
30	2	9·692450	1″ 4	10·307550	9·752789	1″ 5	10·247211	10·060339	1″ 1	9·939661	58	30
31	4	9·692562	2 7	10·307438	9·752937	2 10	10·247063	10·060375	2 2	9·939625	56	29
30	6	9·692674	3 11	10·307326	9·753084	3 15	10·246916	10·060410	3 4	9·939590	54	30
32	8	9·692785	4 15	10·307215	9·753231	4 20	10·246769	10·060446	4 5	9·939554	52	28
30	10	9·692897	5 18	10·307103	9·753379	5 25	10·246621	10·060482	5 6	9·939518	50	30
33	12	9·693008	6 22	10·306992	9·753526	6 29	10·246474	10·060518	6 7	9·939482	48	27
30	14	9·693119	7 26	10·306881	9·753673	7 34	10·246327	10·060554	7 8	9·939446	46	30
34	16	9·693231	8 30	10·306769	9·753820	8 39	10·246180	10·060590	8 10	9·939410	44	26
30	18	9·693342	9 33	10·306658	9·753967	9 44	10·246033	10·060625	9 11	9·939375	42	30
35	20	9·693453	10 37	10·306547	9·754115	10 49	10·245885	10·060661	10 12	9·939339	40	25
30	22	9·693565	11 41	10·306435	9·754262	11 54	10·245738	10·060697	11 13	9·939303	38	30
36	24	9·693676	12 44	10·306324	9·754409	12 59	10·245591	10·060733	12 14	9·939267	36	24
30	26	9·693787	13 48	10·306213	9·754556	13 64	10·245444	10·060769	13 15	9·939231	34	30
37	28	9·693898	14 52	10·306102	9·754703	14 69	10·245297	10·060805	14 17	9·939195	32	23
30	30	9·694009	15 56	10·305991	9·754850	15 73	10·245150	10·060841	15 18	9·939159	30	30
38	32	9·694120	16 59	10·305880	9·754997	16 78	10·245003	10·060877	16 19	9·939123	28	22
30	34	9·694231	17 63	10·305769	9·755144	17 83	10·244856	10·060913	17 20	9·939087	26	30
39	36	9·694342	18 67	10·305658	9·755291	18 88	10·244709	10·060948	18 22	9·939052	24	21
30	38	9·694453	19 70	10·305547	9·755438	19 93	10·244562	10·060984	19 23	9·939016	22	30
40	40	9·694564	20 74	10·305436	9·755585	20 98	10·244415	10·061020	20 24	9·938980	20	20
30	42	9·694675	21 78	10·305325	9·755731	21 103	10·244269	10·061056	21 25	9·938944	18	30
41	44	9·694786	22 81	10·305214	9·755878	22 108	10·244122	10·061092	22 26	9·938908	16	19
30	46	9·694897	23 85	10·305103	9·756025	23 113	10·243975	10·061128	23 28	9·938872	14	30
42	48	9·695007	24 89	10·304993	9·756172	24 118	10·243828	10·061164	24 29	9·938836	12	18
30	50	9·695118	25 93	10·304882	9·756319	25 122	10·243681	10·061200	25 30	9·938800	10	30
43	52	9·695229	26 97	10·304771	9·756465	26 127	10·243535	10·061237	26 31	9·938763	8	17
30	54	9·695339	27 100	10·304661	9·756612	27 132	10·243388	10·061273	27 32	9·938727	6	30
44	56	9·695450	28 104	10·304550	9·756759	28 137	10·243241	10·061309	28 34	9·938691	4	16
30	58	9·695561	29 107	10·304439	9·756905	29 142	10·243095	10·061345	29 35	9·938655	2	30
45	59	9·695671	30 111	10·304329	9·757052	30 147	10·242948	10·061381	30 36	9·938619	1	15
30	2	9·695782	1 4	10·304218	9·757199	1 5	10·242801	10·061417	1 1	9·938583	58	30
46	4	9·695892	2 7	10·304108	9·757345	2 10	10·242655	10·061453	2 2	9·938547	56	14
30	6	9·696003	3 11	10·303997	9·757492	3 15	10·242508	10·061489	3 4	9·938511	54	30
47	8	9·696113	4 15	10·303887	9·757638	4 19	10·242362	10·061525	4 5	9·938475	52	13
30	10	9·696223	5 18	10·303777	9·757785	5 24	10·242215	10·061561	5 6	9·938439	50	30
48	12	9·696334	6 22	10·303666	9·757931	6 29	10·242069	10·061598	6 7	9·938402	48	12
30	14	9·696444	7 26	10·303556	9·758078	7 34	10·241922	10·061634	7 8	9·938366	46	30
49	16	9·696554	8 29	10·303446	9·758224	8 39	10·241776	10·061670	8 10	9·938330	44	11
30	18	9·696664	9 33	10·303336	9·758371	9 44	10·241629	10·061706	9 11	9·938294	42	30
50	20	9·696775	10 37	10·303225	9·758517	10 49	10·241483	10·061742	10 12	9·938258	40	10
30	22	9·696885	11 40	10·303115	9·758663	11 54	10·241337	10·061779	11 13	9·938221	38	30
51	24	9·696995	12 44	10·303005	9·758810	12 58	10·241190	10·061815	12 14	9·938185	36	9
25	26	9·697105	13 48	10·302895	9·758956	13 63	10·241044	10·061851	13 16	9·938149	34	30
52	28	9·697215	14 51	10·302785	9·759102	14 68	10·240898	10·061887	14 17	9·938113	32	8
30	30	9·697325	15 55	10·302675	9·759248	15 73	10·240752	10·061924	15 18	9·938076	30	30
53	32	9·697435	16 59	10·302565	9·759395	16 78	10·240605	10·061960	16 19	9·938040	28	7
30	34	9·697545	17 62	10·302455	9·759541	17 83	10·240459	10·061996	17 20	9·938004	26	30
54	36	9·697654	18 66	10·302346	9·759687	18 88	10·240313	10·062033	18 22	9·937967	24	6
30	38	9·697764	19 70	10·302236	9·759833	19 93	10·240167	10·062069	19 23	9·937931	22	30
55	40	9·697874	20 73	10·302126	9·759979	20 97	10·240021	10·062105	20 24	9·937895	20	5
30	42	9·697984	21 77	10·302016	9·760126	21 102	10·239874	10·062142	21 25	9·937858	18	30
56	44	9·698094	22 81	10·301906	9·760272	22 107	10·239728	10·062178	22 26	9·937822	16	4
30	46	9·698203	23 84	10·301797	9·760418	23 112	10·239582	10·062214	23 28	9·937786	14	30
57	48	9·698313	24 88	10·301687	9·760564	24 117	10·239436	10·062251	24 29	9·937749	12	3
30	50	9·698423	25 92	10·301577	9·760710	25 122	10·239290	10·062287	25 30	9·937713	10	30
58	52	9·698532	26 95	10·301468	9·760856	26 127	10·239144	10·062324	26 31	9·937676	8	2
30	54	9·698642	27 99	10·301358	9·761002	27 131	10·238998	10·062360	27 32	9·937640	6	30
59	56	9·698751	28 103	10·301249	9·761148	28 136	10·238852	10·062396	28 34	9·937604	4	1
30	58	9·698861	29 106	10·301139	9·761293	29 141	10·238707	10·062433	29 35	9·937567	2	30
60	60	9·698970	30 110	10·301030	9·761439	30 146	10·238561	10·062469	30 36	9·937531	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

60° — 4h 0m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2h 0m — 30°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·698970		10·301030	9·761439		10·238561	10·062469		9·937531	60	60
30	2	9·699079	1″ 4	10·300921	9·761585	1″ 5	10·238415	10·062506	1″ 1	9·937494	58	30
1	4	9·699189	2 7	10·300811	9·761731	2 10	10·238269	10·062542	2 2	9·937458	56	59
30	6	9·699298	3 11	10·300702	9·761877	3 15	10·238123	10·062579	3 4	9·937421	54	30
2	8	9·699407	4 14	10·300593	9·762023	4 19	10·237977	10·062615	4 5	9·937385	52	58
30	10	9·699517	5 18	10·300483	9·762168	5 24	10·237832	10·062652	5 6	9·937348	50	30
3	12	9·699626	6 22	10·300374	9·762314	6 29	10·237686	10·062688	6 7	9·937312	48	57
30	14	9·699735	7 25	10·300265	9·762460	7 34	10·237540	10·062725	7 9	9·937275	46	30
4	16	9·699844	8 29	10·300156	9·762606	8 39	10·237394	10·062762	8 10	9·937238	44	56
30	18	9·699953	9 33	10·300047	9·762751	9 44	10·237249	10·062798	9 11	9·937202	42	30
5	20	9·700062	10 36	10·299938	9·762897	10 48	10·237103	10·062835	10 12	9·937165	40	55
30	22	9·700171	11 40	10·299829	9·763043	11 53	10·236957	10·062871	11 13	9·937129	38	30
6	24	9·700280	12 44	10·299720	9·763188	12 58	10·236812	10·062908	12 15	9·937092	36	54
30	26	9·700389	13 47	10·299611	9·763334	13 63	10·236666	10·062944	13 16	9·937056	34	30
7	28	9·700498	14 51	10·299502	9·763479	14 68	10·236521	10·062981	14 17	9·937019	32	53
30	30	9·700607	15 54	10·299393	9·763625	15 73	10·236375	10·063018	15 18	9·936982	30	30
8	32	9·700716	16 58	10·299284	9·763770	16 78	10·236230	10·063054	16 20	9·936946	28	52
30	34	9·700825	17 62	10·299175	9·763916	17 82	10·236084	10·063091	17 21	9·936909	26	30
9	36	9·700933	18 65	10·299067	9·764061	18 87	10·235939	10·063128	18 22	9·936872	24	51
30	38	9·701042	19 69	10·298958	9·764207	19 92	10·235793	10·063164	19 23	9·936836	22	30
10	40	9·701151	20 72	10·298849	9·764352	20 97	10·235648	10·063201	20 24	9·936799	20	50
30	42	9·701259	21 76	10·298741	9·764497	21 102	10·235503	10·063238	21 26	9·936762	18	30
11	44	9·701368	22 80	10·298632	9·764643	22 107	10·235357	10·063275	22 27	9·936725	16	49
30	46	9·701477	23 83	10·298523	9·764788	23 112	10·235212	10·063311	23 28	9·936689	14	30
12	48	9·701585	24 87	10·298415	9·764933	24 116	10·235067	10·063348	24 29	9·936652	12	48
30	50	9·701694	25 91	10·298306	9·765079	25 121	10·234921	10·063385	25 31	9·936615	10	30
13	52	9·701802	26 94	10·298198	9·765224	26 126	10·234776	10·063422	26 32	9·936578	8	47
30	54	9·701911	27 98	10·298089	9·765369	27 131	10·234631	10·063458	27 33	9·936542	6	30
14	56	9·702019	28 101	10·297981	9·765514	28 136	10·234486	10·063495	28 34	9·936505	4	46
30	58	9·702127	29 105	10·297873	9·765660	29 141	10·234340	10·063532	29 35	9·936468	2	30
15	1	9·702236	30 109	10·297764	9·765805	30 145	10·234195	10·063569	30 37	9·936431	59	45
30	2	9·702344	1 4	10·297656	9·765950	1 5	10·234050	10·063606	1 1	9·936394	58	30
16	4	9·702452	2 7	10·297548	9·766095	2 10	10·233905	10·063643	2 2	9·936357	56	44
30	6	9·702561	3 11	10·297439	9·766240	3 14	10·233760	10·063680	3 4	9·936320	54	30
17	8	9·702669	4 14	10·297331	9·766385	4 19	10·233615	10·063716	4 5	9·936284	52	43
30	10	9·702777	5 18	10·297223	9·766530	5 24	10·233470	10·063753	5 6	9·936247	50	30
18	12	9·702885	6 22	10·297115	9·766675	6 29	10·233325	10·063790	6 7	9·936210	48	42
30	14	9·702993	7 25	10·297007	9·766820	7 34	10·233180	10·063827	7 9	9·936173	46	30
19	16	9·703101	8 29	10·296899	9·766965	8 39	10·233035	10·063864	8 10	9·936136	44	41
30	18	9·703209	9 32	10·296791	9·767110	9 43	10·232890	10·063901	9 11	9·936099	42	30
20	20	9·703317	10 36	10·296683	9·767255	10 48	10·232745	10·063938	10 12	9·936062	40	40
30	22	9·703425	11 39	10·296575	9·767400	11 53	10·232600	10·063975	11 14	9·936025	38	30
21	24	9·703533	12 43	10·296467	9·767545	12 58	10·232455	10·064012	12 15	9·935988	36	39
30	26	9·703641	13 47	10·296359	9·767690	13 63	10·232310	10·064049	13 16	9·935951	34	30
22	28	9·703749	14 50	10·296251	9·767834	14 68	10·232166	10·064086	14 17	9·935914	32	38
30	30	9·703856	15 54	10·296144	9·767979	15 72	10·232021	10·064123	15 18	9·935877	30	30
23	32	9·703964	16 57	10·296036	9·768124	16 77	10·231876	10·064160	16 20	9·935840	28	37
30	34	9·704072	17 61	10·295928	9·768269	17 82	10·231731	10·064197	17 21	9·935803	26	30
24	36	9·704179	18 64	10·295821	9·768414	18 87	10·231586	10·064234	18 22	9·935766	24	36
30	38	9·704287	19 68	10·295713	9·768558	19 92	10·231442	10·064271	19 24	9·935729	22	30
25	40	9·704395	20 72	10·295605	9·768703	20 97	10·231297	10·064308	20 25	9·935692	20	35
30	42	9·704502	21 75	10·295498	9·768848	21 101	10·231152	10·064345	21 26	9·935655	18	30
26	44	9·704610	22 79	10·295390	9·768992	22 106	10·231008	10·064382	22 27	9·935618	16	34
30	46	9·704717	23 83	10·295283	9·769137	23 111	10·230863	10·064419	23 28	9·935581	14	30
27	48	9·704825	24 86	10·295175	9·769281	24 116	10·230719	10·064457	24 30	9·935543	12	33
30	50	9·704932	25 90	10·295068	9·769426	25 121	10·230574	10·064494	25 31	9·935506	10	30
28	52	9·705040	26 93	10·294960	9·769571	26 126	10·230429	10·064531	26 32	9·935469	8	32
30	54	9·705147	27 97	10·294853	9·769715	27 130	10·230285	10·064568	27 33	9·935432	6	30
29	56	9·705254	28 100	10·294746	9·769860	28 135	10·230140	10·064605	28 35	9·935395	4	31
30	58	9·705362	29 104	10·294638	9·770004	29 140	10·229996	10·064642	29 36	9·935358	2	30
30	2	9·705469	30 108	10·294531	9·770148	30 145	10·229852	10·064680	30 37	9·935320	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

59° — 3h 58m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2ʰ 2ᵐ — 30°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·705469		10·294531	9·770148		10·229852	10·064680		9·935320	58	30
30	2	9·705576	1″ 4	10·294424	9·770293	1″ 5	10·229707	10·064717	1″ 1	9·935283	58	30
31	4	9·705683	2 7	10·294317	9·770437	2 10	10·229563	10·064754	2 2	9·935246	56	29
30	6	9·705790	3 11	10·294210	9·770582	3 14	10·229418	10·064791	3 4	9·935209	54	30
32	8	9·705898	4 14	10·294102	9·770726	4 19	10·229274	10·064829	4 5	9·935171	52	28
30	10	9·706005	5 18	10·293995	9·770870	5 24	10·229130	10·064866	5 6	9·935134	50	30
33	12	9·706112	6 21	10·293888	9·771015	6 29	10·228985	10·064903	6 7	9·935097	48	27
30	14	9·706219	7 25	10·293781	9·771159	7 34	10·228841	10·064940	7 9	9·935060	46	30
34	16	9·706326	8 28	10·293674	9·771303	8 38	10·228697	10·064978	8 10	9·935022	44	26
30	18	9·706433	9 32	10·293567	9·771448	9 43	10·228552	10·065015	9 11	9·934985	42	30
35	20	9·706539	10 36	10·293461	9·771592	10 48	10·228408	10·065052	10 12	9·934948	40	25
30	22	9·706646	11 39	10·293354	9·771736	11 53	10·228264	10·065090	11 14	9·934910	38	30
36	24	9·706753	12 43	10·293247	9·771880	12 58	10·228120	10·065127	12 15	9·934873	36	24
30	26	9·706860	13 46	10·293140	9·772024	13 62	10·227976	10·065164	13 16	9·934836	34	30
37	28	9·706967	14 50	10·293033	9·772168	14 67	10·227832	10·065202	14 17	9·934798	32	23
30	30	9·707073	15 53	10·292927	9·772312	15 72	10·227688	10·065239	15 19	9·934761	30	30
38	32	9·707180	16 57	10·292820	9·772457	16 77	10·227543	10·065277	16 20	9·934723	28	22
30	34	9·707287	17 61	10·292713	9·772601	17 82	10·227399	10·065314	17 21	9·934686	26	30
39	36	9·707393	18 64	10·292607	9·772745	18 86	10·227255	10·065351	18 22	9·934649	24	21
30	38	9·707500	19 68	10·292500	9·772889	19 91	10·227111	10·065389	19 24	9·934611	22	30
40	40	9·707606	20 71	10·292394	9·773033	20 96	10·226967	10·065426	20 25	9·934574	20	20
30	42	9·707713	21 75	10·292287	9·773177	21 101	10·226823	10·065464	21 26	9·934536	18	30
41	44	9·707819	22 78	10·292181	9·773321	22 106	10·226679	10·065501	22 27	9·934499	16	19
30	46	9·707926	23 82	10·292074	9·773465	23 110	10·226535	10·065539	23 29	9·934461	14	30
42	48	9·708032	24 85	10·291968	9·773608	24 115	10·226392	10·065576	24 30	9·934424	12	18
30	50	9·708139	25 89	10·291861	9·773752	25 120	10·226248	10·065614	25 31	9·934386	10	30
43	52	9·708245	26 92	10·291755	9·773896	26 125	10·226104	10·065651	26 32	9·934349	8	17
30	54	9·708351	27 96	10·291649	9·774040	27 130	10·225960	10·065689	27 34	9·934311	6	30
44	56	9·708458	28 99	10·291542	9·774184	28 134	10·225816	10·065726	28 35	9·934274	4	16
30	58	9·708564	29 103	10·291436	9·774328	29 139	10·225672	10·065764	29 36	9·934236	2	30
45	3	9·708670	30 107	10·291330	9·774471	30 144	10·225529	10·065801	30 37	9·934199	57	15
30	2	9·708776	1 4	10·291224	9·774615	1 5	10·225385	10·065839	1 1	9·934161	58	30
46	4	9·708882	2 7	10·291118	9·774759	2 10	10·225241	10·065877	2 3	9·934123	56	14
30	6	9·708988	3 11	10·291012	9·774902	3 14	10·225098	10·065914	3 4	9·934086	54	30
47	8	9·709094	4 14	10·290906	9·775046	4 19	10·224954	10·065952	4 5	9·934048	52	13
30	10	9·709200	5 18	10·290800	9·775190	5 24	10·224810	10·065989	5 6	9·934011	50	30
48	12	9·709306	6 21	10·290694	9·775333	6 29	10·224667	10·066027	6 8	9·933973	48	12
30	14	9·709412	7 25	10·290588	9·775477	7 33	10·224523	10·066065	7 9	9·933935	46	30
49	16	9·709518	8 28	10·290482	9·775621	8 38	10·224379	10·066102	8 10	9·933898	44	11
30	18	9·709624	9 32	10·290376	9·775764	9 43	10·224236	10·066140	9 11	9·933860	42	30
50	20	9·709730	10 35	10·290270	9·775908	10 48	10·224092	10·066178	10 13	9·933822	40	10
30	22	9·709836	11 39	10·290164	9·776051	11 53	10·223949	10·066216	11 14	9·933784	38	30
51	24	9·709941	12 42	10·290059	9·776195	12 57	10·223805	10·066253	12 15	9·933747	36	9
30	26	9·710047	13 46	10·289953	9·776338	13 62	10·223662	10·066291	13 16	9·933709	34	30
52	28	9·710153	14 49	10·289847	9·776482	14 67	10·223518	10·066329	14 18	9·933671	32	8
30	30	9·710259	15 53	10·289741	9·776625	15 72	10·223375	10·066367	15 19	9·933633	30	30
53	32	9·710364	16 56	10·289636	9·776768	16 76	10·223232	10·066404	16 20	9·933596	28	7
30	34	9·710470	17 60	10·289530	9·776912	17 81	10·223088	10·066442	17 21	9·933558	26	30
54	36	9·710575	18 63	10·289425	9·777055	18 86	10·222945	10·066480	18 23	9·933520	24	6
30	38	9·710681	19 67	10·289319	9·777199	19 91	10·222801	10·066518	19 24	9·933482	22	30
55	40	9·710786	20 70	10·289214	9·777342	20 96	10·222658	10·066555	20 25	9·933445	20	5
30	42	9·710892	21 74	10·289108	9·777485	21 100	10·222515	10·066593	21 26	9·933407	18	30
56	44	9·710997	22 77	10·289003	9·777628	22 105	10·222372	10·066631	22 28	9·933369	16	4
30	46	9·711103	23 81	10·288897	9·777772	23 110	10·222228	10·066669	23 29	9·933331	14	30
57	48	9·711208	24 85	10·288792	9·777915	24 115	10·222085	10·066707	24 30	9·933293	12	3
30	50	9·711313	25 88	10·288687	9·778058	25 119	10·221942	10·066745	25 32	9·933255	10	30
58	52	9·711419	26 92	10·288581	9·778201	26 124	10·221799	10·066783	26 33	9·933217	8	2
30	54	9·711524	27 95	10·288476	9·778344	27 129	10·221656	10·066821	27 34	9·933179	6	30
59	56	9·711629	28 99	10·288371	9·778488	28 134	10·221512	10·066859	28 35	9·933141	4	1
30	58	9·711734	29 102	10·288266	9·778631	29 139	10·221369	10·066896	29 37	9·933104	2	30
60	4	9·711839	30 106	10·288161	9·778774	30 143	10·221226	10·066934	30 38	9·933066	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

59° — 3ʰ 56ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2ʰ 4ᵐ — 31°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·711839		10·288161	9·778774		10·221226	10·066934		9·933066	56	60
30	2	9·711944	1″ 3	10·288056	9·778917	1″ 5	10·221083	10·066972	1″ 1	9·933028	58	30
1	4	9·712050	2 7	10·287950	9·779060	2 10	10·220940	10·067010	2 3	9·932990	56	59
30	6	9·712155	3 10	10·287845	9·779203	3 14	10·220797	10·067048	3 4	9·932952	54	30
2	8	9·712260	4 14	10·287740	9·779346	4 19	10·220654	10·067086	4 5	9·932914	52	58
30	10	9·712365	5 17	10·287635	9·779489	5 24	10·220511	10·067124	5 6	9·932876	50	30
3	12	9·712469	6 21	10·287531	9·779632	6 29	10·220368	10·067162	6 8	9·932838	48	57
30	14	9·712574	7 24	10·287426	9·779775	7 33	10·220225	10·067200	7 9	9·932800	46	30
4	16	9·712679	8 28	10·287321	9·779918	8 38	10·220082	10·067238	8 10	9·932762	44	56
30	18	9·712784	9 31	10·287216	9·780061	9 43	10·219939	10·067276	9 11	9·932724	42	30
5	20	9·712889	10 35	10·287111	9·780203	10 48	10·219797	10·067315	10 13	9·932685	40	55
30	22	9·712994	11 38	10·287006	9·780346	11 52	10·219654	10·067353	11 14	9·932647	38	30
6	24	9·713098	12 42	10·286902	9·780489	12 57	10·219511	10·067391	12 15	9·932609	36	54
30	26	9·713203	13 45	10·286797	9·780632	13 62	10·219368	10·067429	13 17	9·932571	34	30
7	28	9·713308	14 49	10·286692	9·780775	14 67	10·219225	10·067467	14 18	9·932533	32	53
30	30	9·713412	15 52	10·286588	9·780917	15 71	10·219083	10·067505	15 19	9·932495	30	30
8	32	9·713517	16 56	10·286483	9·781060	16 76	10·218940	10·067543	16 20	9·932457	28	52
30	34	9·713621	17 59	10·286379	9·781203	17 81	10·218797	10·067581	17 22	9·932419	26	30
9	36	9·713726	18 63	10·286274	9·781346	18 86	10·218654	10·067620	18 23	9·932380	24	51
30	38	9·713831	19 66	10·286169	9·781488	19 90	10·218512	10·067658	19 24	9·932342	22	30
10	40	9·713935	20 70	10·286065	9·781631	20 95	10·218369	10·067696	20 25	9·932304	20	50
30	42	9·714039	21 73	10·285961	9·781774	21 100	10·218226	10·067734	21 27	9·932266	18	30
11	44	9·714144	22 77	10·285856	9·781916	22 105	10·218084	10·067772	22 28	9·932228	16	49
30	46	9·714248	23 80	10·285752	9·782059	23 109	10·217941	10·067811	23 29	9·932189	14	30
12	48	9·714352	24 84	10·285648	9·782201	24 114	10·217799	10·067849	24 30	9·932151	12	48
30	50	9·714457	25 87	10·285543	9·782344	25 119	10·217656	10·067887	25 32	9·932113	10	30
13	52	9·714561	26 91	10·285439	9·782486	26 124	10·217514	10·067925	26 33	9·932075	8	47
30	54	9·714665	27 94	10·285335	9·782629	27 129	10·217371	10·067964	27 34	9·932036	6	30
14	56	9·714769	28 98	10·285231	9·782771	28 133	10·217229	10·068002	28 36	9·931998	4	46
30	58	9·714873	29 101	10·285127	9·782914	29 138	10·217086	10·068040	29 37	9·931960	2	30
15	5	9·714978	30 105	10·285022	9·783056	30 143	10·216944	10·068079	30 38	9·931921	55	45
30	2	9·715082	1 3	10·284918	9·783199	1 5	10·216801	10·068117	1 1	9·931883	58	30
16	4	9·715186	2 7	10·284814	9·783341	2 9	10·216659	10·068155	2 3	9·931845	56	44
30	6	9·715290	3 10	10·284710	9·783483	3 14	10·216517	10·068194	3 4	9·931806	54	30
17	8	9·715394	4 14	10·284606	9·783626	4 19	10·216374	10·068232	4 5	9·931768	52	43
30	10	9·715498	5 17	10·284502	9·783768	5 24	10·216232	10·068270	5 6	9·931730	50	30
18	12	9·715602	6 21	10·284398	9·783910	6 28	10·216090	10·068309	6 8	9·931691	48	42
30	14	9·715705	7 24	10·284295	9·784053	7 33	10·215947	10·068347	7 9	9·931653	46	30
19	16	9·715809	8 28	10·284191	9·784195	8 38	10·215805	10·068386	8 10	9·931614	44	41
30	18	9·715913	9 31	10·284087	9·784337	9 43	10·215663	10·068424	9 12	9·931576	42	30
20	20	9·716017	10 35	10·283983	9·784479	10 47	10·215521	10·068463	10 13	9·931537	40	40
30	22	9·716121	11 38	10·283879	9·784622	11 52	10·215378	10·068501	11 14	9·931499	38	30
21	24	9·716224	12 42	10·283776	9·784764	12 57	10·215236	10·068540	12 15	9·931460	36	39
30	26	9·716328	13 45	10·283672	9·784906	13 62	10·215094	10·068578	13 17	9·931422	34	30
22	28	9·716432	14 49	10·283568	9·785048	14 66	10·214952	10·068617	14 18	9·931383	32	38
30	30	9·716535	15 52	10·283465	9·785190	15 71	10·214810	10·068655	15 19	9·931345	30	30
23	32	9·716639	16 56	10·283361	9·785332	16 76	10·214668	10·068694	16 21	9·931306	28	37
30	34	9·716742	17 59	10·283258	9·785474	17 81	10·214526	10·068732	17 22	9·931268	26	30
24	36	9·716846	18 63	10·283154	9·785616	18 85	10·214384	10·068771	18 23	9·931229	24	36
30	38	9·716949	19 66	10·283051	9·785758	19 90	10·214242	10·068809	19 24	9·931191	22	30
25	40	9·717053	20 69	10·282947	9·785900	20 95	10·214100	10·068848	20 26	9·931152	20	35
30	42	9·717156	21 72	10·282844	9·786042	21 100	10·213958	10·068886	21 27	9·931114	18	30
26	44	9·717259	22 76	10·282741	9·786184	22 104	10·213816	10·068925	22 28	9·931075	16	34
30	46	9·717363	23 79	10·282637	9·786326	23 109	10·213674	10·068964	23 30	9·931036	14	30
27	48	9·717466	24 83	10·282534	9·786468	24 114	10·213532	10·069002	24 31	9·930998	12	33
30	50	9·717569	25 86	10·282431	9·786610	25 118	10·213390	10·069041	25 32	9·930959	10	30
28	52	9·717673	26 90	10·282327	9·786752	26 123	10·213248	10·069079	26 33	9·930921	8	32
30	54	9·717776	27 93	10·282224	9·786894	27 128	10·213106	10·069118	27 35	9·930882	6	30
29	56	9·717879	28 97	10·282121	9·787036	28 133	10·212964	10·069157	28 36	9·930843	4	31
30	58	9·717982	29 100	10·282018	9·787178	29 137	10·212822	10·069196	29 37	9·930804	2	30
30	6	9·718085	30 104	10·281915	9·787319	30 142	10·212681	10·069234	30 39	9·930766	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

58° — 3ʰ 54ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2h 6m					31°							
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·718085		10·281915	9·787319		10·212681	10·069234		9·930766	60	30
30	2	9·718188	1″ 3	10·281812	9·787461	1″ 5	10·212539	10·069273	1″ 1	9·930727	58	30
31	4	9·718291	2 7	10·281709	9·787603	2 9	10·212397	10·069312	2 3	9·930688	56	29
30	6	9·718394	3 10	10·281606	9·787745	3 14	10·212255	10·069350	3 4	9·930650	54	30
32	8	9·718497	4 14	10·281503	9·787886	4 19	10·212114	10·069389	4 5	9·930611	52	28
30	10	9·718600	5 17	10·281400	9·788028	5 24	10·211972	10·069428	5 6	9·930572	50	30
33	12	9·718703	6 20	10·281297	9·788170	6 28	10·211830	10·069467	6 8	9·930533	48	27
30	14	9·718806	7 24	10·281194	9·788311	7 33	10·211689	10·069506	7 9	9·930495	46	30
34	16	9·718909	8 27	10·281091	9·788453	8 38	10·211547	10·069544	8 10	9·930456	44	26
30	18	9·719011	9 31	10·280989	9·788595	9 42	10·211405	10·069583	9 12	9·930417	42	30
35	20	9·719114	10 34	10·280886	9·788736	10 47	10·211264	10·069622	10 13	9·930378	40	25
30	22	9·719217	11 38	10·280783	9·788878	11 52	10·211122	10·069661	11 14	9·930339	38	30
36	24	9·719320	12 41	10·280680	9·789019	12 57	10·210981	10·069700	12 16	9·930300	36	24
30	26	9·719422	13 44	10·280578	9·789161	13 61	10·210839	10·069739	13 17	9·930262	34	30
37	28	9·719525	14 48	10·280475	9·789302	14 66	10·210698	10·069777	14 18	9·930223	32	23
30	30	9·719627	15 51	10·280372	9·789444	15 71	10·210556	10·069816	15 20	9·930184	30	30
38	32	9·719730	16 55	10·280270	9·789585	16 75	10·210415	10·069855	16 21	9·930145	28	22
30	34	9·719833	17 58	10·280167	9·789727	17 80	10·210273	10·069894	17 22	9·930106	26	30
39	36	9·719935	18 62	10·280065	9·789868	18 85	10·210132	10·069933	18 23	9·930067	24	21
30	38	9·720038	19 65	10·279962	9·790009	19 89	10·209991	10·069972	19 25	9·930028	22	30
40	40	9·720140	20 68	10·279860	9·790151	20 94	10·209849	10·070011	20 26	9·929989	20	20
30	42	9·720242	21 72	10·279758	9·790292	21 99	10·209708	10·070050	21 27	9·929950	18	30
41	44	9·720345	22 75	10·279655	9·790434	22 104	10·209566	10·070089	22 29	9·929911	16	19
30	46	9·720447	23 79	10·279553	9·790575	23 108	10·209425	10·070128	23 30	9·929872	14	30
42	48	9·720549	24 82	10·279451	9·790716	24 113	10·209284	10·070167	24 31	9·929833	12	18
30	50	9·720652	25 86	10·279348	9·790857	25 118	10·209143	10·070206	25 32	9·929794	10	30
43	52	9·720754	26 89	10·279246	9·790999	26 122	10·209001	10·070245	26 34	9·929755	8	17
30	54	9·720856	27 92	10·279144	9·791140	27 127	10·208860	10·070284	27 35	9·929716	6	30
44	56	9·720958	28 96	10·279042	9·791281	28 132	10·208719	10·070323	28 36	9·929677	4	16
30	58	9·721060	29 99	10·278940	9·791422	29 137	10·208578	10·070362	29 38	9·929638	2	30
45	0	9·721162	30 103	10·278838	9·791563	30 141	10·208437	10·070401	30 39	9·929599	60	15
30	2	9·721264	1 3	10·278736	9·791705	1 5	10·208295	10·070440	1 1	9·929560	58	30
46	4	9·721366	2 7	10·278634	9·791846	2 9	10·208154	10·070479	2 3	9·929521	56	14
30	6	9·721468	3 10	10·278532	9·791987	3 14	10·208013	10·070519	3 4	9·929482	54	30
47	8	9·721570	4 14	10·278430	9·792128	4 19	10·207872	10·070558	4 5	9·929442	52	13
30	10	9·721672	5 17	10·278328	9·792269	5 23	10·207731	10·070597	5 6	9·929403	50	30
48	12	9·721774	6 20	10·278226	9·792410	6 28	10·207590	10·070636	6 8	9·929364	48	12
30	14	9·721876	7 24	10·278124	9·792551	7 33	10·207449	10·070675	7 9	9·929325	46	30
49	16	9·721978	8 27	10·278022	9·792692	8 38	10·207308	10·070714	8 10	9·929286	44	11
30	18	9·722080	9 30	10·277920	9·792833	9 42	10·207167	10·070754	9 12	9·929247	42	30
50	20	9·722181	10 34	10·277819	9·792974	10 47	10·207026	10·070793	10 13	9·929207	40	10
30	22	9·722283	11 37	10·277717	9·793115	11 52	10·206885	10·070832	11 14	9·929168	38	30
51	24	9·722385	12 41	10·277615	9·793256	12 56	10·206744	10·070871	12 16	9·929129	36	9
30	26	9·722487	13 44	10·277513	9·793397	13 61	10·206603	10·070910	13 17	9·929090	34	30
52	28	9·722588	14 48	10·277412	9·793538	14 66	10·206462	10·070950	14 18	9·929050	32	8
30	30	9·722690	15 51	10·277310	9·793679	15 70	10·206321	10·070989	15 20	9·929011	30	30
53	32	9·722791	16 55	10·277209	9·793819	16 75	10·206181	10·071028	16 21	9·928972	28	7
30	34	9·722893	17 58	10·277107	9·793960	17 80	10·206040	10·071068	17 22	9·928933	26	30
54	36	9·722994	18 61	10·277006	9·794101	18 84	10·205899	10·071107	18 24	9·928893	24	6
30	38	9·723096	19 64	10·276904	9·794242	19 89	10·205758	10·071146	19 25	9·928854	22	30
55	40	9·723197	20 68	10·276803	9·794383	20 94	10·205617	10·071185	20 26	9·928815	20	5
30	42	9·723299	21 71	10·276701	9·794523	21 98	10·205477	10·071225	21 28	9·928775	18	30
56	44	9·723400	22 75	10·276600	9·794664	22 103	10·205336	10·071264	22 29	9·928736	16	4
30	46	9·723501	23 78	10·276499	9·794805	23 108	10·205195	10·071304	23 30	9·928696	14	30
57	48	9·723603	24 82	10·276397	9·794946	24 113	10·205054	10·071343	24 31	9·928657	12	3
30	50	9·723704	25 85	10·276296	9·795086	25 117	10·204914	10·071382	25 33	9·928618	10	30
58	52	9·723805	26 89	10·276195	9·795227	26 122	10·204773	10·071422	26 34	9·928578	8	2
30	54	9·723906	27 92	10·276094	9·795367	27 127	10·204633	10·071461	27 35	9·928539	6	30
59	56	9·724007	28 95	10·275993	9·795508	28 131	10·204492	10·071501	28 37	9·928499	4	1
30	58	9·724109	29 98	10·275891	9·795649	29 136	10·204351	10·071540	29 38	9·928460	2	30
60	0	9·724210	30 102	10·275790	9·795789	30 141	10·204211	10·071580	30 39	9·928420	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
					58°					3h 52m		

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2^h 8^m — 32°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	8	9·724210		10·275790	9·795789		10·204211	10·071580		9·928420	52	60
30	2	9·724311	1″ 3	10·275689	9·795930	1″ 5	10·204070	10·071619	1″ 1	9·928381	58	30
1	4	9·724412	2 7	10·275588	9·796070	2 9	10·203930	10·071658	2 3	9·928342	56	59
30	6	9·724513	3 10	10·275487	9·796211	3 14	10·203789	10·071698	3 4	9·928302	54	30
2	8	9·724614	4 13	10·275386	9·796351	4 19	10·203649	10·071737	4 5	9·928263	52	58
30	10	9·724715	5 17	10·275285	9·796492	5 23	10·203508	10·071777	5 7	9·928223	50	30
3	12	9·724816	6 20	10·275184	9·796632	6 28	10·203368	10·071817	6 8	9·928183	48	57
30	14	9·724917	7 23	10·275083	9·796773	7 33	10·203227	10·071856	7 9	9·928144	46	30
4	16	9·725017	8 27	10·274983	9·796913	8 37	10·203087	10·071896	8 11	9·928104	44	56
30	18	9·725118	9 30	10·274882	9·797053	9 42	10·202947	10·071935	9 12	9·928065	42	30
5	20	9·725219	10 34	10·274781	9·797194	10 47	10·202806	10·071975	10 13	9·928025	40	55
30	22	9·725320	11 37	10·274680	9·797334	11 51	10·202666	10·072015	11 15	9·927986	38	30
6	24	9·725420	12 40	10·274580	9·797475	12 56	10·202526	10·072054	12 16	9·927946	36	54
30	26	9·725521	13 44	10·274479	9·797615	13 61	10·202385	10·072094	13 17	9·927906	34	30
7	28	9·725622	14 47	10·274378	9·797755	14 65	10·202245	10·072133	14 18	9·927867	32	53
30	30	9·725722	15 50	10·274278	9·797895	15 70	10·202105	10·072173	15 20	9·927827	30	30
8	32	9·725823	16 54	10·274177	9·798036	16 75	10·201964	10·072213	16 21	9·927787	28	52
30	34	9·725923	17 57	10·274076	9·798176	17 79	10·201824	10·072252	17 22	9·927748	26	30
9	36	9·726024	18 61	10·273976	9·798316	18 84	10·201684	10·072292	18 24	9·927708	24	51
30	38	9·726124	19 64	10·273875	9·798456	19 89	10·201544	10·072332	19 25	9·927668	22	30
10	40	9·726225	20 67	10·273775	9·798596	20 93	10·201404	10·072371	20 26	9·927629	20	50
30	42	9·726325	21 70	10·273675	9·798737	21 98	10·201264	10·072411	21 28	9·927589	18	30
11	44	9·726426	22 74	10·273574	9·798877	22 103	10·201123	10·072451	22 29	9·927549	16	49
30	46	9·726526	23 77	10·273474	9·799017	23 107	10·200983	10·072491	23 30	9·927509	14	30
12	48	9·726626	24 80	10·273374	9·799157	24 112	10·200843	10·072530	24 32	9·927470	12	48
30	50	9·726727	25 84	10·273273	9·799297	25 117	10·200703	10·072570	25 33	9·927430	10	30
13	52	9·726827	26 87	10·273173	9·799437	26 122	10·200563	10·072610	26 34	9·927390	8	47
30	54	9·726927	27 90	10·273073	9·799577	27 126	10·200423	10·072650	27 36	9·927350	6	30
14	56	9·727027	28 94	10·272973	9·799717	28 131	10·200283	10·072690	28 37	9·927310	4	46
30	58	9·727128	29 97	10·272872	9·799857	29 136	10·200143	10·072730	29 38	9·927270	2	30
15	9	9·727228	30 101	10·272772	9·799997	30 140	10·200003	10·072769	30 40	9·927231	52	45
30	2	9·727328	1 3	10·272672	9·800137	1 5	10·199863	10·072809	1 1	9·927191	58	30
16	4	9·727428	2 7	10·272572	9·800277	2 9	10·199723	10·072849	2 3	9·927151	56	44
30	6	9·727528	3 10	10·272472	9·800417	3 14	10·199583	10·072889	3 4	9·927111	54	30
17	8	9·727628	4 13	10·272372	9·800557	4 19	10·199443	10·072929	4 5	9·927071	52	43
30	10	9·727728	5 17	10·272272	9·800697	5 23	10·199303	10·072969	5 7	9·927031	50	30
18	12	9·727828	6 20	10·272172	9·800836	6 28	10·199164	10·073009	6 8	9·926991	48	42
30	14	9·727928	7 23	10·272072	9·800976	7 33	10·199024	10·073049	7 9	9·926951	46	30
19	16	9·728027	6 27	10·271972	9·801116	8 37	10·198884	10·073089	8 11	9·926911	44	41
30	18	9·728127	9 30	10·271873	9·801256	9 42	10·198744	10·073129	9 12	9·926871	42	30
20	20	9·728227	10 33	10·271773	9·801396	10 46	10·198604	10·073169	10 13	9·926831	40	40
30	22	9·728327	11 37	10·271673	9·801535	11 51	10·198465	10·073209	11 15	9·926791	38	30
21	24	9·728427	12 40	10·271573	9·801675	12 56	10·198325	10·073249	12 16	9·926751	36	39
30	26	9·728526	13 43	10·271474	9·801815	13 60	10·198185	10·073289	13 17	9·926711	34	30
22	28	9·728626	14 47	10·271374	9·801955	14 65	10·198045	10·073329	14 19	9·926671	32	38
30	30	9·728726	15 50	10·271274	9·802094	15 70	10·197906	10·073369	15 20	9·926631	30	30
23	32	9·728825	16 53	10·271175	9·802234	16 74	10·197766	10·073409	16 21	9·926591	28	37
30	34	9·728925	17 56	10·271075	9·802374	17 79	10·197626	10·073449	17 23	9·926551	26	30
24	36	9·729024	18 59	10·270976	9·802513	18 84	10·197487	10·073489	18 24	9·926511	24	36
30	38	9·729124	19 63	10·270876	9·802653	19 88	10·197347	10·073529	19 25	9·926471	22	30
25	40	9·729223	20 66	10·270777	9·802792	20 93	10·197208	10·073569	20 27	9·926431	20	35
30	42	9·729323	21 70	10·270677	9·802932	21 98	10·197068	10·073609	21 28	9·926391	18	30
26	44	9·729422	22 73	10·270578	9·803072	22 102	10·196928	10·073649	22 29	9·926351	16	34
30	46	9·729522	23 76	10·270478	9·803211	23 107	10·196789	10·073689	23 31	9·926311	14	30
27	48	9·729621	24 80	10·270379	9·803351	24 112	10·196649	10·073730	24 32	9·926270	12	33
30	50	9·729720	25 83	10·270280	9·803490	25 116	10·196510	10·073770	25 33	9·926230	10	30
28	52	9·729820	26 86	10·270180	9·803630	26 121	10·196370	10·073810	26 35	9·926190	8	32
30	54	9·729919	27 90	10·270081	9·803769	27 126	10·196231	10·073850	27 36	9·926150	6	30
29	56	9·730018	28 93	10·269982	9·803909	28 130	10·196091	10·073890	28 38	9·926110	4	31
30	58	9·730117	29 96	10·269883	9·804048	29 135	10·195952	10·073931	29 39	9·926069	2	30
30	10	9·730217	30 100	10·269784	9·804187	30 139	10·195813	10·073971	30 40	9·926029	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

57° — 3^h 50^m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2h 10m						32°						
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·730217		10·269783	9·804187		10·195813	10·073971		9·926029	50	30
30	2	9·730316	1″ 3	10·269684	9·804327	1″ 5	10·195673	10·074011	1″ 1	9·925989	58	30
31	4	9·730415	2 7	10·269585	9·804466	2 9	10·195534	10·074051	2 3	9·925949	56	29
30	6	9·730514	3 10	10·269486	9·804605	3 14	10·195395	10·074092	3 4	9·925908	54	30
32	8	9·730613	4 13	10·269387	9·804745	4 19	10·195255	10·074132	4 5	9·925868	52	28
30	10	9·730712	5 16	10·269288	9·804884	5 23	10·195116	10·074172	5 7	9·925828	50	30
33	12	9·730811	6 20	10·269189	9·805023	6 28	10·194977	10·074212	6 8	9·925788	48	27
30	14	9·730910	7 23	10·269090	9·805163	7 32	10·194837	10·074253	7 9	9·925747	46	30
34	16	9·731009	8 26	10·268991	9·805302	8 37	10·194698	10·074293	8 11	9·925707	44	26
30	18	9·731108	9 30	10·268892	9·805441	9 42	10·194559	10·074333	9 12	9·925667	42	30
35	20	9·731206	10 33	10·268794	9·805580	10 46	10·194420	10·074374	10 13	9·925626	40	25
30	22	9·731305	11 36	10·268695	9·805719	11 51	10·194281	10·074414	11 15	9·925586	38	30
36	24	9·731404	12 40	10·268596	9·805859	12 56	10·194141	10·074455	12 16	9·925545	36	24
30	26	9·731503	13 43	10·268497	9·805998	13 60	10·194002	10·074495	13 18	9·925505	34	30
37	28	9·731602	14 46	10·268398	9·806137	14 65	10·193863	10·074535	14 19	9·925465	32	23
30	30	9·731700	15 49	10·268300	9·806276	15 70	10·193724	10·074576	15 20	9·925424	30	30
38	32	9·731799	16 53	10·268201	9·806415	16 74	10·193585	10·074616	16 22	9·925384	28	22
30	34	9·731897	17 56	10·268102	9·806554	17 79	10·193446	10·074657	17 23	9·925343	26	30
39	36	9·731996	18 59	10·268004	9·806693	18 83	10·193307	10·074697	18 24	9·925303	24	21
30	38	9·732095	19 63	10·267905	9·806832	19 88	10·193168	10·074738	19 26	9·925262	22	30
40	40	9·732193	20 66	10·267807	9·806971	20 93	10·193029	10·074778	20 27	9·925222	20	20
30	42	9·732292	21 69	10·267708	9·807110	21 97	10·192890	10·074819	21 28	9·925181	18	30
41	44	9·732390	22 73	10·267610	9·807249	22 102	10·192751	10·074859	22 30	9·925141	16	19
30	46	9·732489	23 76	10·267511	9·807388	23 107	10·192612	10·074900	23 31	9·925100	14	30
42	48	9·732587	24 79	10·267413	9·807527	24 111	10·192473	10·074940	24 32	9·925060	12	18
30	50	9·732685	25 82	10·267315	9·807666	25 116	10·192334	10·074981	25 34	9·925019	10	30
43	52	9·732784	26 86	10·267216	9·807805	26 121	10·192195	10·075021	26 35	9·924979	8	17
30	54	9·732882	27 89	10·267118	9·807944	27 125	10·192056	10·075062	27 36	9·924938	6	30
44	56	9·732980	28 92	10·267020	9·808083	28 130	10·191917	10·075103	28 38	9·924897	4	16
30	58	9·733079	29 95	10·266921	9·808222	29 134	10·191778	10·075143	29 39	9·924857	2	30
45	11	9·733177	30 99	10·266823	9·808361	30 139	10·191639	10·075184	30 40	9·924816	49	15
30	2	9·733275	1 3	10·266725	9·808499	1 5	10·191501	10·075224	1 1	9·924776	58	30
46	4	9·733373	2 6	10·266627	9·808638	2 9	10·191362	10·075265	2 3	9·924735	56	14
30	6	9·733471	3 10	10·266529	9·808777	3 14	10·191223	10·075306	3 4	9·924694	54	30
47	8	9·733569	4 13	10·266431	9·808916	4 18	10·191084	10·075346	4 5	9·924654	52	13
30	10	9·733667	5 16	10·266333	9·809055	5 23	10·190945	10·075387	5 7	9·924613	50	30
48	12	9·733765	6 20	10·266235	9·809193	6 28	10·190807	10·075428	6 8	9·924572	48	12
30	14	9·733863	7 23	10·266137	9·809332	7 32	10·190668	10·075469	7 10	9·924531	46	30
49	16	9·733961	8 26	10·266039	9·809471	8 37	10·190529	10·075509	8 11	9·924491	44	11
30	18	9·734059	9 29	10·265941	9·809609	9 42	10·190391	10·075550	9 12	9·924450	42	30
50	20	9·734157	10 33	10·265843	9·809748	10 46	10·190252	10·075591	10 14	9·924409	40	10
30	22	9·734255	11 36	10·265745	9·809887	11 51	10·190113	10·075632	11 15	9·924368	38	30
51	24	9·734353	12 39	10·265647	9·810025	12 55	10·189975	10·075672	12 16	9·924328	36	9
30	26	9·734451	13 42	10·265549	9·810164	13 60	10·189836	10·075713	13 18	9·924287	34	30
52	28	9·734549	14 46	10·265451	9·810302	14 65	10·189698	10·075754	14 19	9·924246	32	8
30	30	9·734646	15 49	10·265354	9·810441	15 69	10·189559	10·075795	15 20	9·924205	30	30
53	32	9·734744	16 52	10·265256	9·810580	16 74	10·189420	10·075836	16 22	9·924164	28	7
30	34	9·734842	17 55	10·265158	9·810718	17 79	10·189282	10·075876	17 23	9·924124	26	30
54	36	9·734939	18 59	10·265061	9·810857	18 83	10·189143	10·075917	18 24	9·924083	24	6
30	38	9·735037	19 62	10·264963	9·810995	19 88	10·189005	10·075958	19 26	9·924042	22	30
55	40	9·735135	20 65	10·264865	9·811134	20 92	10·188866	10·075999	20 27	9·924001	20	5
30	42	9·735232	21 68	10·264768	9·811272	21 97	10·188728	10·076040	21 29	9·923960	18	30
56	44	9·735330	22 72	10·264670	9·811410	22 102	10·188590	10·076081	22 30	9·923919	16	4
30	46	9·735427	23 75	10·264573	9·811549	23 106	10·188451	10·076122	23 31	9·923878	14	30
57	48	9·735525	24 78	10·264475	9·811687	24 111	10·188313	10·076163	24 33	9·923837	12	3
30	50	9·735622	25 82	10·264378	9·811826	25 116	10·188174	10·076204	25 34	9·923796	10	30
58	52	9·735719	26 85	10·264281	9·811964	26 120	10·188036	10·076245	26 35	9·923755	8	2
30	54	9·735817	27 88	10·264183	9·812102	27 125	10·187898	10·076286	27 37	9·923714	6	30
59	56	9·735914	28 91	10·264086	9·812241	28 129	10·187759	10·076327	28 38	9·923673	4	1
30	58	9·736011	29 95	10·263989	9·812379	29 134	10·187621	10·076368	29 39	9·923632	2	30
60	12	9·736109	30 98	10·263891	9·812517	30 139	10·187483	10·076409	30 41	9·923591	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
						57°					3h 48m	

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.												
2^h 12^m						33°						
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·736109		10·263891	9·812517		10·187483	10·076409		9·923591	48	60
30	2	9·736206	1″ 3	10·263794	9·812656	1″ 5	10·187344	10·076450	1″ 1	9·923550	58	30
1	4	9·736303	2 6	10·263697	9·812794	2 9	10·187206	10·076491	2 3	9·923509	56	59
30	6	9·736400	3 10	10·263600	9·812932	3 14	10·187068	10·076532	3 4	9·923468	54	30
2	8	9·736498	4 13	10·263502	9·813070	4 18	10·186930	10·076573	4 5	9·923427	52	58
30	10	9·736595	5 16	10·263405	9·813209	5 23	10·186791	10·076614	5 7	9·923386	50	30
3	12	9·736692	6 19	10·263308	9·813347	6 28	10·186653	10·076655	6 8	9·923345	48	57
30	14	9·736789	7 23	10·263211	9·813485	7 32	10·186515	10·076696	7 10	9·923304	46	30
4	16	9·736886	8 26	10·263114	9·813623	8 37	10·186377	10·076737	8 11	9·923263	44	56
30	18	9·736983	9 29	10·263017	9·813761	9 41	10·186239	10·076778	9 12	9·923222	42	30
5	20	9·737080	10 32	10·262920	9·813899	10 46	10·186101	10·076819	10 14	9·923181	40	55
30	22	9·737177	11 36	10·262823	9·814037	11 51	10·185963	10·076861	11 15	9·923139	38	30
6	24	9·737274	12 39	10·262726	9·814176	12 55	10·185824	10·076902	12 17	9·923098	36	54
30	26	9·737371	13 42	10·262629	9·814314	13 60	10·185686	10·076943	13 18	9·923057	34	30
7	28	9·737467	14 45	10·262533	9·814452	14 64	10·185548	10·076984	14 19	9·923016	32	53
30	30	9·737564	15 48	10·262436	9·814590	15 69	10·185410	10·077025	15 21	9·922975	30	30
8	32	9·737661	16 51	10·262339	9·814728	16 74	10·185272	10·077067	16 22	9·922933	28	52
30	34	9·737758	17 55	10·262242	9·814866	17 78	10·185134	10·077108	17 23	9·922892	26	30
9	36	9·737855	18 58	10·262145	9·815004	18 83	10·184996	10·077149	18 25	9·922851	24	51
30	38	9·737951	19 61	10·262049	9·815142	19 87	10·184858	10·077190	19 26	9·922810	22	30
10	40	9·738048	20 64	10·261952	9·815280	20 92	10·184720	10·077232	20 27	9·922768	20	50
30	42	9·738145	21 68	10·261855	9·815417	21 97	10·184583	10·077273	21 29	9·922727	18	30
11	44	9·738241	22 71	10·261759	9·815555	22 101	10·184445	10·077314	22 30	9·922686	16	49
30	46	9·738338	23 74	10·261662	9·815693	23 106	10·184307	10·077356	23 32	9·922644	14	30
12	48	9·738434	24 77	10·261566	9·815831	24 110	10·184169	10·077397	24 33	9·922603	12	48
30	50	9·738531	25 81	10·261469	9·815969	25 115	10·184031	10·077438	25 34	9·922562	10	30
13	52	9·738627	26 84	10·261373	9·816107	26 120	10·183893	10·077480	26 36	9·922520	8	47
30	54	9·738724	27 87	10·261276	9·816245	27 124	10·183755	10·077521	27 37	9·922479	6	30
14	56	9·738820	28 90	10·261180	9·816382	28 129	10·183618	10·077562	28 38	9·922438	4	46
30	58	9·738917	29 94	10·261083	9·816520	29 133	10·183480	10·077604	29 40	9·922396	2	30
15	13	9·739013	30 97	10·260987	9·816658	30 138	10·183342	10·077645	30 41	9·922355	47	45
30	2	9·739109	1 3	10·260891	9·816796	1 5	10·183204	10·077687	1 1	9·922313	58	30
16	4	9·739206	2 6	10·260794	9·816933	2 9	10·183067	10·077728	2 3	9·922272	56	44
30	6	9·739302	3 10	10·260698	9·817071	3 14	10·182929	10·077769	3 4	9·922231	54	30
17	8	9·739398	4 13	10·260602	9·817209	4 18	10·182791	10·077811	4 6	9·922189	52	43
30	10	9·739494	5 16	10·260506	9·817347	5 23	10·182653	10·077852	5 7	9·922148	50	30
18	12	9·739590	6 19	10·260410	9·817484	6 27	10·182516	10·077894	6 8	9·922106	48	42
30	14	9·739687	7 22	10·260313	9·817622	7 32	10·182378	10·077935	7 10	9·922065	46	30
19	16	9·739783	8 26	10·260217	9·817759	8 37	10·182241	10·077977	8 11	9·922023	44	41
30	18	9·739879	9 29	10·260121	9·817897	9 41	10·182103	10·078018	9 13	9·921982	42	30
20	20	9·739975	10 32	10·260025	9·818035	10 46	10·181965	10·078060	10 14	9·921940	40	40
30	22	9·740071	11 35	10·259929	9·818172	11 50	10·181828	10·078101	11 15	9·921899	38	30
21	24	9·740167	12 38	10·259833	9·818310	12 55	10·181690	10·078143	12 17	9·921857	36	39
30	26	9·740263	13 42	10·259737	9·818447	13 60	10·181553	10·078185	13 18	9·921815	34	30
22	28	9·740359	14 45	10·259641	9·818585	14 64	10·181415	10·078226	14 19	9·921774	32	38
30	30	9·740455	15 48	10·259545	9·818722	15 69	10·181278	10·078268	15 21	9·921732	30	30
23	32	9·740550	16 51	10·259450	9·818860	16 73	10·181140	10·078309	16 22	9·921691	28	37
30	34	9·740646	17 54	10·259354	9·818997	17 78	10·181003	10·078351	17 24	9·921649	26	30
24	36	9·740742	18 57	10·259258	9·819135	18 82	10·180865	10·078393	18 25	9·921607	24	36
30	38	9·740838	19 61	10·259162	9·819272	19 87	10·180728	10·078434	19 26	9·921566	22	30
25	40	9·740934	20 64	10·259066	9·819410	20 92	10·180590	10·078476	20 28	9·921524	20	35
30	42	9·741029	21 67	10·258971	9·819547	21 96	10·180453	10·078518	21 29	9·921482	18	30
26	44	9·741125	22 70	10·258875	9·819684	22 101	10·180316	10·078559	22 31	9·921441	16	34
30	46	9·741221	23 74	10·258779	9·819822	23 105	10·180178	10·078601	23 32	9·921399	14	30
27	48	9·741316	24 77	10·258684	9·819959	24 110	10·180041	10·078643	24 33	9·921357	12	33
30	50	9·741412	25 80	10·258588	9·820096	25 114	10·179904	10·078685	25 35	9·921315	10	30
28	52	9·741508	26 83	10·258492	9·820234	26 119	10·179766	10·078726	26 36	9·921274	8	32
30	54	9·741603	27 86	10·258397	9·820371	27 124	10·179629	10·078768	27 38	9·921232	6	30
29	56	9·741699	28 89	10·258301	9·820508	28 128	10·179492	10·078810	28 39	9·921190	4	31
30	58	9·741794	29 93	10·258206	9·820646	29 133	10·179354	10·078852	29 40	9·921148	2	30
30	14	9·741889	30 96	10·258111	9·820783	30 137	10·179217	10·078893	30 42	9·921107	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
						56°					3^h 46^m	

TABLE XXXVII.—(*continued*).

LOG. SINES. COSINES, &c.

2h 14m — 33°

″′	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	″′
30	0	9·741889		10·258111	9·820783		10·179217	10·078893		9·921107	46	30
30	2	9·741985	1″ 3	10·258015	9·820920	1″ 5	10·179080	10·078935	1″ 1	9·921065	58	30
31	4	9·742080	2 6	10·257920	9·821057	2 9	10·178943	10·078977	2 3	9·921023	56	29
30	6	9·742176	3 9	10·257824	9·821195	3 14	10·178805	10·079019	3 4	9·920981	54	30
32	8	9·742271	4 13	10·257729	9·821332	4 18	10·178668	10·079061	4 6	9·920939	52	28
30	10	9·742366	5 16	10·257634	9·821469	5 23	10·178531	10·079103	5 7	9·920897	50	30
33	12	9·742462	6 19	10·257538	9·821606	6 27	10·178394	10·079144	6 8	9·920856	48	27
30	14	9·742557	7 22	10·257443	9·821743	7 32	10·178257	10·079186	7 10	9·920814	46	30
34	16	9·742652	8 25	10·257348	9·821880	8 37	10·178120	10·079228	8 11	9·920772	44	26
30	18	9·742747	9 28	10·257253	9·822017	9 41	10·177983	10·079270	9 13	9·920730	42	30
35	20	9·742842	10 32	10·257158	9·822154	10 46	10·177846	10·079312	10 14	9·920688	40	25
30	22	9·742937	11 35	10·257063	9·822292	11 50	10·177708	10·079354	11 15	9·920646	38	30
36	24	9·743033	12 38	10·256967	9·822429	12 55	10·177571	10·079396	12 17	9·920604	36	24
30	26	9·743128	13 41	10·256872	9·822566	13 59	10·177434	10·079438	13 18	9·920562	34	30
37	28	9·743223	14 44	10·256777	9·822703	14 64	10·177297	10·079480	14 20	9·920520	32	23
30	30	9·743318	15 48	10·256682	9·822840	15 69	10·177160	10·079522	15 21	9·920478	30	30
38	32	9·743413	16 51	10·256587	9·822977	16 73	10·177023	10·079564	16 22	9·920436	28	22
30	34	9·743508	17 54	10·256492	9·823114	17 78	10·176886	10·079606	17 24	9·920394	26	30
39	36	9·743602	18 57	10·256398	9·823251	18 82	10·176749	10·079648	18 25	9·920352	24	21
30	38	9·743697	19 60	10·256303	9·823387	19 87	10·176613	10·079690	19 27	9·920310	22	30
40	40	9·743792	20 63	10·256208	9·823524	20 91	10·176476	10·079732	20 28	9·920268	20	20
30	42	9·743887	21 67	10·256113	9·823661	21 96	10·176339	10·079774	21 29	9·920226	18	30
41	44	9·743982	22 70	10·256018	9·823798	22 101	10·176202	10·079816	22 31	9·920184	16	19
30	46	9·744077	23 73	10·255923	9·823935	23 105	10·176065	10·079859	23 32	9·920141	14	30
42	48	9·744171	24 76	10·255829	9·824072	24 110	10·175928	10·079901	24 34	9·920099	12	18
30	50	9·744266	25 79	10·255734	9·824209	25 114	10·175791	10·079943	25 35	9·920057	10	30
43	52	9·744361	26 82	10·255639	9·824345	26 119	10·175655	10·079985	26 36	9·920015	8	17
30	54	9·744455	27 86	10·255545	9·824482	27 123	10·175518	10·080027	27 38	9·919973	6	30
44	56	9·744550	28 89	10·255450	9·824619	28 128	10·175381	10·080069	28 39	9·919931	4	16
30	58	9·744644	29 92	10·255356	9·824756	29 133	10·175244	10·080111	29 41	9·919889	2	30
45	25	9·744739	30 95	10·255261	9·824893	30 137	10·175107	10·080154	30 42	9·919846	45	15
30	2	9·744833	1 3	10·255167	9·825029	1 5	10·174971	10·080196	1 1	9·919804	58	30
46	4	9·744928	2 6	10·255072	9·825166	2 9	10·174834	10·080238	2 3	9·919762	56	14
30	6	9·745022	3 9	10·254978	9·825303	3 14	10·174697	10·080280	3 4	9·919720	54	30
47	8	9·745117	4 13	10·254883	9·825439	4 18	10·174561	10·080323	4 6	9·919677	52	13
30	10	9·745211	5 16	10·254789	9·825576	5 23	10·174424	10·080365	5 7	9·919635	50	30
48	12	9·745306	6 19	10·254694	9·825713	6 27	10·174287	10·080407	6 8	9·919593	48	12
30	14	9·745400	7 22	10·254600	9·825849	7 32	10·174151	10·080449	7 10	9·919551	46	30
49	16	9·745494	8 25	10·254506	9·825986	8 36	10·174014	10·080492	8 11	9·919508	44	11
30	18	9·745589	9 28	10·254411	9·826123	9 41	10·173877	10·080534	9 13	9·919466	42	30
50	20	9·745683	10 31	10·254317	9·826259	10 45	10·173741	10·080576	10 14	9·919424	40	10
30	22	9·745777	11 35	10·254223	9·826396	11 50	10·173604	10·080619	11 16	9·919381	38	30
51	24	9·745871	12 38	10·254129	9·826532	12 55	10·173468	10·080661	12 17	9·919339	36	9
30	26	9·745965	13 41	10·254035	9·826669	13 59	10·173331	10·080703	13 18	9·919297	34	30
52	28	9·746060	14 44	10·253940	9·826805	14 64	10·173195	10·080746	14 20	9·919254	32	8
30	30	9·746154	15 47	10·253846	9·826942	15 68	10·173058	10·080788	15 21	9·919212	30	30
53	32	9·746248	16 50	10·253752	9·827078	16 73	10·172922	10·080831	16 23	9·919169	28	7
30	34	9·746342	17 53	10·253658	9·827215	17 77	10·172785	10·080873	17 24	9·919127	26	30
54	36	9·746436	18 56	10·253564	9·827351	18 82	10·172649	10·080915	18 25	9·919085	24	6
30	38	9·746530	19 60	10·253470	9·827488	19 86	10·172512	10·080958	19 27	9·919042	22	30
55	40	9·746624	20 63	10·253376	9·827624	20 91	10·172376	10·081000	20 28	9·919000	20	5
30	42	9·746718	21 66	10·253282	9·827761	21 96	10·172239	10·081043	21 30	9·918957	18	30
56	44	9·746812	22 69	10·253188	9·827897	22 100	10·172103	10·081085	22 31	9·918915	16	4
30	46	9·746905	23 72	10·253095	9·828033	23 105	10·171967	10·081128	23 32	9·918872	14	30
57	48	9·746999	24 75	10·253001	9·828170	24 109	10·171830	10·081170	24 34	9·918830	12	3
30	50	9·747093	25 79	10·252907	9·828306	25 114	10·171694	10·081213	25 35	9·918787	10	30
58	52	9·747187	26 82	10·252813	9·828442	26 118	10·171558	10·081255	26 37	9·918745	8	2
30	54	9·747281	27 85	10·252719	9·828579	27 123	10·171421	10·081298	27 38	9·918702	6	30
59	56	9·747374	28 88	10·252626	9·828715	28 127	10·171285	10·081341	28 39	9·918659	4	1
30	58	9·747468	29 91	10·252532	9·828851	29 132	10·171149	10·081383	29 41	9·918617	2	30
60	26	9·747562	30 94	10·252438	9·828987	30 136	10·171013	10·081426	30 42	9·918574	0	0
″′	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	″′

56° — 3h 44m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2^h 16^m — 84°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·747562		10·252438	9·828987		10·171013	10·081426		9·918574	44	60
30	2	9·747655	1″ 3	10·252345	9·829124	1″ 5	10·170876	10·081468	1″ 1	9·918532	58	30
1	4	9·747749	2 6	10·252251	9·829260	2 9	10·170740	10·081511	2 3	9·918489	56	59
30	6	9·747842	3 9	10·252158	9·829396	3 14	10·170604	10·081554	3 4	9·918446	54	30
2	8	9·747936	4 12	10·252064	9·829532	4 18	10·170468	10·081596	4 6	9·918404	52	58
30	10	9·748030	5 16	10·251970	9·829669	5 23	10·170331	10·081639	5 7	9·918361	50	30
3	12	9·748123	6 19	10·251877	9·829805	6 27	10·170195	10·081682	6 9	9·918318	48	57
30	14	9·748216	7 22	10·251784	9·829941	7 32	10·170059	10·081724	7 10	9·918276	46	30
4	16	9·748310	8 25	10·251690	9·830077	8 36	10·169923	10·081767	8 11	9·918233	44	56
30	18	9·748403	9 28	10·251597	9·830213	9 41	10·169787	10·081810	9 13	9·918190	42	30
5	20	9·748497	10 31	10·251503	9·830349	10 45	10·169651	10·081853	10 14	9·918147	40	55
30	22	9·748590	11 34	10·251410	9·830485	11 50	10·169515	10·081895	11 16	9·918105	38	30
6	24	9·748683	12 37	10·251317	9·830621	12 54	10·169379	10·081938	12 17	9·918062	36	54
30	26	9·748777	13 40	10·251223	9·830757	13 59	10·169243	10·081981	13 19	9·918019	34	30
7	28	9·748870	14 43	10·251130	9·830893	14 63	10·169107	10·082024	14 20	9·917976	32	53
30	30	9·748963	15 47	10·251037	9·831029	15 68	10·168971	10·082066	15 21	9·917934	30	30
8	32	9·749056	16 50	10·250944	9·831165	16 72	10·168835	10·082109	16 23	9·917891	28	52
30	34	9·749149	17 53	10·250851	9·831301	17 77	10·168699	10·082152	17 24	9·917848	26	30
9	36	9·749243	18 56	10·250757	9·831437	18 82	10·168563	10·082195	18 26	9·917805	24	51
30	38	9·749336	19 59	10·250664	9·831573	19 86	10·168427	10·082238	19 27	9·917762	22	30
10	40	9·749429	20 62	10·250571	9·831709	20 91	10·168291	10·082281	20 29	9·917719	20	50
30	42	9·749522	21 65	10·250478	9·831845	21 95	10·168155	10·082324	21 30	9·917677	18	30
11	44	9·749615	22 68	10·250385	9·831981	22 100	10·168019	10·082366	22 31	9·917634	16	49
30	46	9·749708	23 72	10·250292	9·832117	23 104	10·167883	10·082409	23 33	9·917591	14	30
12	48	9·749801	24 75	10·250199	9·832253	24 109	10·167747	10·082452	24 34	9·917548	12	48
30	50	9·749894	25 78	10·250106	9·832389	25 113	10·167611	10·082495	25 36	9·917505	10	30
13	52	9·749987	26 81	10·250013	9·832525	26 118	10·167475	10·082538	26 37	9·917462	8	47
30	54	9·750079	27 84	10·249921	9·832660	27 122	10·167340	10·082581	27 39	9·917419	6	30
14	56	9·750172	28 87	10·249828	9·832796	28 127	10·167204	10·082624	28 40	9·917376	4	46
30	58	9·750265	29 90	10·249735	9·832932	29 131	10·167068	10·082667	29 41	9·917333	2	30
15	17	9·750358	30 93	10·249642	9·833068	30 136	10·166932	10·082710	30 43	9·917290	43	45
30	2	9·750451	1 3	10·249549	9·833204	1 5	10·166796	10·082753	1 1	9·917247	58	30
16	4	9·750543	2 6	10·249457	9·833339	2 9	10·166661	10·082796	2 3	9·917204	56	44
30	6	9·750636	3 9	10·249364	9·833475	3 14	10·166525	10·082839	3 4	9·917161	54	30
17	8	9·750729	4 12	10·249271	9·833611	4 18	10·166389	10·082882	4 6	9·917118	52	43
30	10	9·750821	5 15	10·249179	9·833747	5 23	10·166253	10·082925	5 7	9·917075	50	30
18	12	9·750914	6 18	10·249086	9·833882	6 27	10·166118	10·082968	6 9	9·917032	48	42
30	14	9·751007	7 21	10·248993	9·834018	7 32	10·165982	10·083011	7 10	9·916989	46	30
19	16	9·751099	8 25	10·248901	9·834154	8 36	10·165846	10·083054	8 12	9·916946	44	41
30	18	9·751192	9 28	10·248808	9·834289	9 41	10·165711	10·083098	9 13	9·916902	42	30
20	20	9·751284	10 31	10·248716	9·834425	10 45	10·165575	10·083141	10 14	9·916859	40	40
30	22	9·751377	11 34	10·248623	9·834561	11 50	10·165440	10·083184	11 16	9·916816	38	30
21	24	9·751469	12 37	10·248531	9·834696	12 54	10·165304	10·083227	12 17	9·916773	36	39
30	26	9·751561	13 40	10·248439	9·834832	13 59	10·165168	10·083270	13 19	9·916730	34	30
22	28	9·751654	14 43	10·248346	9·834967	14 63	10·165033	10·083313	14 20	9·916687	32	38
30	30	9·751746	15 46	10·248254	9·835103	15 68	10·164897	10·083357	15 22	9·916643	30	30
23	32	9·751839	16 49	10·248161	9·835238	16 72	10·164762	10·083400	16 23	9·916600	28	37
30	34	9·751931	17 52	10·248069	9·835374	17 77	10·164626	10·083443	17 24	9·916557	26	30
24	36	9·752023	18 55	10·247977	9·835509	18 81	10·164491	10·083486	18 26	9·916514	24	36
30	38	9·752115	19 59	10·247885	9·835645	19 86	10·164355	10·083530	19 27	9·916470	22	30
25	40	9·752208	20 62	10·247792	9·835780	20 90	10·164220	10·083573	20 29	9·916427	20	35
30	42	9·752300	21 65	10·247700	9·835916	21 95	10·164084	10·083616	21 30	9·916384	18	30
26	44	9·752392	22 68	10·247608	9·836051	22 99	10·163949	10·083659	22 32	9·916341	16	34
30	46	9·752484	23 71	10·247516	9·836187	23 104	10·163813	10·083703	23 33	9·916297	14	30
27	48	9·752576	24 74	10·247424	9·836322	24 108	10·163678	10·083746	24 35	9·916254	12	33
30	50	9·752668	25 77	10·247332	9·836458	25 113	10·163542	10·083789	25 36	9·916211	10	30
28	52	9·752760	26 80	10·247240	9·836593	26 118	10·163407	10·083833	26 37	9·916167	8	32
30	54	9·752852	27 83	10·247148	9·836728	27 122	10·163272	10·083876	27 39	9·916124	6	30
29	56	9·752944	28 86	10·247056	9·836864	28 127	10·163136	10·083920	28 40	9·916081	4	31
30	58	9·753036	29 89	10·246964	9·836999	29 131	10·163001	10·083963	29 42	9·916037	2	30
30	18	9·753128	30 92	10·246872	9·837134	30 136	10·162866	10·084006	30 43	9·915994	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

55° — 3^h 42^m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2h 18m						34°						
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·753128		10·246872	9·837134		10·162866	10·084006		9·915994	42	30
30	2	9·753220	1″ 3	10·246780	9·837270	1″ 4	10·162730	10·084050	1″ 1	9·915950	58	30
31	4	9·753312	2 6	10·246688	9·837405	2 9	10·162595	10·084093	2 3	9·915907	56	29
30	6	9·753404	3 9	10·246596	9·837540	3 13	10·162460	10·084137	3 4	9·915863	54	30
32	8	9·753495	4 12	10·246505	9·837675	4 18	10·162325	10·084180	4 6	9·915820	52	28
30	10	9·753587	5 15	10·246413	9·837811	5 22	10·162189	10·084224	5 7	9·915776	50	30
33	12	9·753679	6 18	10·246321	9·837946	6 27	10·162054	10·084267	6 9	9·915733	48	27
30	14	9·753771	7 21	10·246229	9·838081	7 31	10·161919	10·084311	7 10	9·915689	46	30
34	16	9·753862	8 24	10·246138	9·838216	8 36	10·161784	10·084354	8 12	9·915646	44	26
30	18	9·753954	9 27	10·246046	9·838352	9 40	10·161648	10·084398	9 13	9·915602	42	30
35	20	9·754046	10 30	10·245954	9·838487	10 45	10·161513	10·084441	10 15	9·915559	40	25
30	22	9·754137	11 34	10·245863	9·838622	11 49	10·161378	10·084485	11 16	9·915515	38	30
36	24	9·754229	12 37	10·245771	9·838757	12 54	10·161243	10·084528	12 17	9·915472	36	24
30	26	9·754320	13 40	10·245680	9·838892	13 58	10·161108	10·084572	13 19	9·915428	34	30
37	28	9·754412	14 43	10·245588	9·839027	14 63	10·160973	10·084615	14 20	9·915385	32	23
30	30	9·754503	15 46	10·245497	9·839162	15 67	10·160838	10·084659	15 22	9·915341	30	30
38	32	9·754595	16 49	10·245405	9·839297	16 72	10·160703	10·084703	16 23	9·915297	28	22
30	34	9·754686	17 52	10·245314	9·839433	17 76	10·160567	10·084746	17 25	9·915254	26	30
39	36	9·754778	18 55	10·245222	9·839568	18 81	10·160432	10·084790	18 26	9·915210	24	21
30	38	9·754869	19 58	10·245131	9·839703	19 85	10·160297	10·084834	19 28	9·915166	22	30
40	40	9·754960	20 61	10·245040	9·839838	20 90	10·160162	10·084877	20 29	9·915123	20	20
30	42	9·755052	21 64	10·244948	9·839973	21 94	10·160027	10·084921	21 30	9·915079	18	30
41	44	9·755143	22 67	10·244857	9·840108	22 99	10·159892	10·084965	22 32	9·915035	16	19
30	46	9·755234	23 70	10·244766	9·840243	23 103	10·159757	10·085008	23 33	9·914992	14	30
42	48	9·755326	24 73	10·244674	9·840378	24 108	10·159622	10·085052	24 35	9·914948	12	18
30	50	9·755417	25 76	10·244583	9·840513	25 112	10·159487	10·085096	25 36	9·914904	10	30
43	52	9·755508	26 79	10·244492	9·840648	26 117	10·159352	10·085140	26 38	9·914860	8	17
30	54	9·755599	27 82	10·244401	9·840782	27 121	10·159218	10·085183	27 39	9·914817	6	30
44	56	9·755690	28 85	10·244310	9·840917	28 126	10·159083	10·085227	28 40	9·914773	4	16
30	58	9·755781	29 88	10·244219	9·841052	29 130	10·158948	10·085271	29 42	9·914729	2	30
45	19	9·755872	30 91	10·244128	9·841187	30 135	10·158813	10·085315	30 44	9·914685	42	15
30	2	9·755963	1 3	10·244037	9·841322	1 4	10·158678	10·085359	1 1	9·914641	58	30
46	4	9·756054	2 6	10·243946	9·841457	2 9	10·158543	10·085402	2 3	9·914598	56	14
30	6	9·756145	3 9	10·243855	9·841592	3 13	10·158408	10·085446	3 4	9·914554	54	30
47	8	9·756236	4 12	10·243764	9·841727	4 18	10·158273	10·085490	4 6	9·914510	52	13
30	10	9·756327	5 15	10·243673	9·841861	5 22	10·158139	10·085534	5 7	9·914466	50	30
48	12	9·756418	6 18	10·243582	9·841996	6 27	10·158004	10·085578	6 9	9·914422	48	12
30	14	9·756509	7 21	10·243491	9·842131	7 31	10·157869	10·085622	7 10	9·914378	46	30
49	16	9·756600	8 24	10·243400	9·842266	8 36	10·157734	10·085666	8 12	9·914334	44	11
30	18	9·756691	9 27	10·243309	9·842400	9 40	10·157600	10·085710	9 13	9·914290	42	30
50	20	9·756782	10 30	10·243218	9·842535	10 45	10·157465	10·085754	10 15	9·914246	40	10
30	22	9·756872	11 33	10·243128	9·842670	11 49	10·157330	10·085798	11 16	9·914202	38	30
51	24	9·756963	12 36	10·243037	9·842805	12 54	10·157195	10·085842	12 18	9·914158	36	9
30	26	9·757054	13 39	10·242946	9·842939	13 58	10·157061	10·085886	13 19	9·914114	34	30
52	28	9·757144	14 42	10·242856	9·843074	14 63	10·156926	10·085930	14 21	9·914070	32	8
30	30	9·757235	15 45	10·242765	9·843209	15 67	10·156791	10·085974	15 22	9·914026	30	30
53	32	9·757326	16 48	10·242674	9·843343	16 72	10·156657	10·086018	16 24	9·913982	28	7
30	34	9·757416	17 51	10·242584	9·843478	17 76	10·156522	10·086062	17 25	9·913938	26	30
54	36	9·757507	18 54	10·242493	9·843612	18 81	10·156388	10·086106	18 26	9·913894	24	6
30	38	9·757597	19 57	10·242403	9·843747	19 85	10·156253	10·086150	19 28	9·913850	22	30
55	40	9·757688	20 60	10·242312	9·843882	20 90	10·156118	10·086194	20 29	9·913806	20	5
30	42	9·757778	21 63	10·242222	9·844016	21 94	10·155984	10·086238	21 31	9·913762	18	30
56	44	9·757869	22 66	10·242131	9·844151	22 99	10·155849	10·086282	22 32	9·913718	16	4
30	46	9·757959	23 69	10·242041	9·844285	23 103	10·155715	10·086326	23 34	9·913674	14	30
57	48	9·758050	24 72	10·241950	9·844420	24 108	10·155580	10·086370	24 35	9·913630	12	3
30	50	9·758140	25 76	10·241860	9·844554	25 112	10·155446	10·086415	25 37	9·913585	10	30
58	52	9·758230	26 79	10·241770	9·844689	26 117	10·155311	10·086459	26 38	9·913541	8	2
30	54	9·758321	27 82	10·241679	9·844823	27 121	10·155177	10·086503	27 40	9·913497	6	30
59	56	9·758411	28 85	10·241589	9·844958	28 126	10·155042	10·086547	28 41	9·913453	4	1
30	58	9·758501	29 88	10·241499	9·845092	29 130	10·154908	10·086591	29 43	9·913409	2	30
60	20	9·758591	30 91	10·241409	9·845227	30 135	10·154773	10·086635	30 44	9·913365	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
						55°				3h 40m		

TABLE XXXVII.—(continued).

LOG. SINES, COSINES, &c.

2ʰ 20ᵐ — 35°

″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang	Secant	Parts	Cosine	m. s.	″
0	0	9·758591		10·241409	9·845227		10·154773	10·086635		9·913365	40	60
30	2	9·758681	1″ 3	10·241319	9·845361	1″ 4	10·154639	10·086680	1″ 1	9·913320	58	30
1	4	9·758772	2 6	10·241228	9·845496	2 9	10·154504	10·086724	2 3	9·913276	56	59
30	6	9·758862	3 9	10·241138	9·845630	3 13	10·154370	10·086768	3 4	9·913232	54	30
2	8	9·758952	4 12	10·241048	9·845764	4 18	10·154236	10·086813	4 6	9·913187	52	58
30	10	9·759042	5 15	10·240958	9·845899	5 22	10·154101	10·086857	5 7	9·913143	50	30
3	12	9·759132	6 18	10·240868	9·846033	6 27	10·153967	10·086901	6 9	9·913099	48	57
30	14	9·759222	7 21	10·240778	9·846168	7 31	10·153832	10·086945	7 10	9·913055	46	30
4	16	9·759312	8 24	10·240688	9·846302	8 36	10·153698	10·086990	8 12	9·913010	44	56
30	18	9·759402	9 27	10·240598	9·846436	9 40	10·153564	10·087034	9 13	9·912966	42	30
5	20	9·759492	10 30	10·240508	9·846570	10 45	10·153430	10·087078	10 15	9·912922	40	55
30	22	9·759582	11 33	10·240418	9·846705	11 49	10·153295	10·087123	11 16	9·912877	38	30
6	24	9·759672	12 36	10·240328	9·846839	12 54	10·153161	10·087167	12 18	9·912833	36	54
30	26	9·759762	13 39	10·240238	9·846973	13 58	10·153027	10·087212	13 19	9·912788	34	30
7	28	9·759852	14 42	10·240148	9·847108	14 63	10·152892	10·087256	14 21	9·912744	32	53
30	30	9·759941	15 45	10·240059	9·847242	15 67	10·152758	10·087300	15 22	9·912700	30	30
8	32	9·760031	16 48	10·239969	9·847376	16 72	10·152624	10·087345	16 24	9·912655	28	52
30	34	9·760121	17 51	10·239879	9·847510	17 76	10·152490	10·087389	17 25	9·912611	26	30
9	36	9·760211	18 54	10·239789	9·847644	18 80	10·152356	10·087434	18 27	9·912566	24	51
30	38	9·760300	19 57	10·239700	9·847779	19 85	10·152221	10·087478	19 28	9·912522	22	30
10	40	9·760390	20 60	10·239610	9·847913	20 89	10·152087	10·087523	20 30	9·912477	20	50
30	42	9·760480	21 63	10·239520	9·848047	21 94	10·151953	10·087567	21 31	9·912433	18	30
11	44	9·760569	22 66	10·239431	9·848181	22 98	10·151819	10·087612	22 33	9·912388	16	49
30	46	9·760659	23 69	10·239341	9·848315	23 103	10·151685	10·087656	23 34	9·912344	14	30
12	48	9·760748	24 72	10·239252	9·848449	24 107	10·151551	10·087701	24 36	9·912299	12	48
30	50	9·760838	25 75	10·239162	9·848583	25 112	10·151417	10·087746	25 37	9·912255	10	30
13	52	9·760927	26 78	10·239073	9·848717	26 116	10·151283	10·087790	26 38	9·912210	8	47
30	54	9·761017	27 81	10·238983	9·848851	27 121	10·151149	10·087835	27 40	9·912165	6	30
14	56	9·761106	28 84	10·238894	9·848986	28 125	10·151014	10·087879	28 41	9·912121	4	46
30	58	9·761196	29 87	10·238804	9·849120	29 130	10·150880	10·087924	29 43	9·912076	2	30
15	21	9·761285	30 90	10·238715	9·849254	30 134	10·150746	10·087969	30 44	9·912031	39	45
30	2	9·761374	1 3	10·238626	9·849388	1 4	10·150612	10·088013	1 1	9·911987	58	30
16	4	9·761464	2 6	10·238536	9·849522	2 9	10·150478	10·088058	2 3	9·911942	56	44
30	6	9·761553	3 9	10·238447	9·849656	3 13	10·150344	10·088103	3 4	9·911897	54	30
17	8	9·761642	4 12	10·238358	9·849790	4 18	10·150210	10·088147	4 6	9·911853	52	43
30	10	9·761732	5 15	10·238268	9·849924	5 22	10·150076	10·088192	5 7	9·911808	50	30
18	12	9·761821	6 18	10·238179	9·850057	6 27	10·149943	10·088237	6 9	9·911763	48	42
30	14	9·761910	7 21	10·238090	9·850191	7 31	10·149809	10·088281	7 10	9·911719	46	30
19	16	9·761999	8 24	10·238001	9·850325	8 36	10·149675	10·088326	8 12	9·911674	44	41
30	18	9·762088	9 27	10·237912	9·850459	9 40	10·149541	10·088371	9 13	9·911629	42	30
20	20	9·762177	10 30	10·237823	9·850593	10 45	10·149407	10·088416	10 15	9·911584	40	40
30	22	9·762267	11 33	10·237733	9·850727	11 49	10·149273	10·088460	11 16	9·911540	38	30
21	24	9·762356	12 36	10·237644	9·850861	12 54	10·149139	10·088505	12 18	9·911495	36	39
30	26	9·762445	13 38	10·237555	9·850995	13 58	10·149005	10·088550	13 19	9·911450	34	30
22	28	9·762534	14 41	10·237466	9·851129	14 62	10·148871	10·088595	14 21	9·911405	32	38
30	30	9·762623	15 44	10·237377	9·851262	15 67	10·148738	10·088640	15 22	9·911360	30	30
23	32	9·762712	16 47	10·237288	9·851396	16 71	10·148604	10·088685	16 24	9·911315	28	37
30	34	9·762801	17 50	10·237199	9·851530	17 76	10·148470	10·088729	17 25	9·911271	26	30
24	36	9·762889	18 53	10·237111	9·851664	18 80	10·148336	10·088774	18 27	9·911226	24	36
30	38	9·762978	19 56	10·237022	9·851797	19 85	10·148203	10·088819	19 28	9·911181	22	30
25	40	9·763067	20 59	10·236933	9·851931	20 89	10·148069	10·088864	20 30	9·911136	20	35
30	42	9·763156	21 62	10·236844	9·852065	21 94	10·147935	10·088909	21 31	9·911091	18	30
26	44	9·763245	22 65	10·236755	9·852199	22 98	10·147801	10·088954	22 33	9·911046	16	34
30	46	9·763333	23 68	10·236667	9·852332	23 103	10·147668	10·088999	23 34	9·911001	14	30
27	48	9·763422	24 71	10·236578	9·852466	24 107	10·147534	10·089044	24 36	9·910956	12	33
30	50	9·763511	25 74	10·236489	9·852600	25 111	10·147400	10·089089	25 37	9·910911	10	30
28	52	9·763600	26 77	10·236400	9·852733	26 116	10·147267	10·089134	26 39	9·910866	8	32
30	54	9·763688	27 80	10·236312	9·852867	27 120	10·147133	10·089179	27 40	9·910821	6	30
29	56	9·763777	28 83	10·236223	9·853001	28 125	10·146999	10·089224	28 42	9·910776	4	31
30	58	9·763865	29 86	10·236135	9·853134	29 129	10·146866	10·089269	29 43	9·910731	2	30
30	22	9·763954	30 89	10·236046	9·853268	30 134	10·146732	10·089314	30 45	9·910686	0	30
″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	″

54° — 3ʰ 38ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

$2^h\ 22^m$ — 35°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·763954		10·236046	9·853268		10·146732	10·089314		9·910686	38	30
30	2	9·764043	1″ 3	10·235957	9·853402	1″ 4	10·146598	10·089359	1″ 2	9·910641	58	30
31	4	9·764131	2 6	10·235869	9·853535	2 9	10·146465	10·089404	2 3	9·910596	56	29
30	6	9·764220	3 9	10·235780	9·853669	3 13	10·146331	10·089449	3 5	9·910551	54	30
32	8	9·764308	4 12	10·235692	9·853802	4 18	10·146198	10·089494	4 6	9·910506	52	28
30	10	9·764396	5 15	10·235604	9·853936	5 22	10·146064	10·089539	5 8	9·910461	50	30
33	12	9·764485	6 18	10·235515	9·854069	6 27	10·145931	10·089585	6 9	9·910415	48	27
30	14	9·764573	7 21	10·235427	9·854203	7 31	10·145797	10·089630	7 11	9·910370	46	30
34	16	9·764662	8 24	10·235338	9·854336	8 36	10·145664	10·089675	8 12	9·910325	44	26
30	18	9·764750	9 26	10·235250	9·854470	9 40	10·145530	10·089720	9 14	9·910280	42	30
35	20	9·764838	10 29	10·235162	9·854603	10 44	10·145397	10·089765	10 15	9·910235	40	25
30	22	9·764926	11 32	10·235074	9·854737	11 49	10·145263	10·089810	11 17	9·910190	38	30
36	24	9·765015	12 35	10·234985	9·854870	12 53	10·145130	10·089856	12 18	9·910144	36	24
30	26	9·765103	13 38	10·234897	9·855004	13 58	10·144996	10·089901	13 20	9·910099	34	30
37	28	9·765191	14 41	10·234809	9·855137	14 62	10·144863	10·089946	14 21	9·910054	32	23
30	30	9·765279	15 44	10·234721	9·855271	15 67	10·144729	10·089991	15 23	9·910009	30	30
38	32	9·765367	16 47	10·234633	9·855404	16 71	10·144596	10·090037	16 24	9·909963	28	22
30	34	9·765456	17 50	10·234544	9·855537	17 76	10·144463	10·090082	17 26	9·909918	26	30
39	36	9·765544	18 53	10·234456	9·855671	18 80	10·144329	10·090127	18 27	9·909873	24	21
30	38	9·765632	19 56	10·234368	9·855804	19 85	10·144196	10·090173	19 29	9·909827	22	30
40	40	9·765720	20 59	10·234280	9·855938	20 89	10·144062	10·090218	20 30	9·909782	20	20
30	42	9·765808	21 62	10·234192	9·856071	21 93	10·143929	10·090263	21 32	9·909737	18	30
41	44	9·765896	22 65	10·234104	9·856204	22 98	10·143796	10·090309	22 33	9·909691	16	19
30	46	9·765984	23 68	10·234016	9·856338	23 102	10·143662	10·090354	23 35	9·909646	14	30
42	48	9·766072	24 71	10·233928	9·856471	24 107	10·143529	10·090399	24 36	9·909601	12	18
30	50	9·766159	25 74	10·233841	9·856604	25 111	10·143396	10·090445	25 38	9·909555	10	30
43	52	9·766247	26 76	10·233753	9·856737	26 116	10·143263	10·090490	26 39	9·909510	8	17
30	54	9·766335	27 79	10·233665	9·856871	27 120	10·143129	10·090536	27 41	9·909464	6	30
44	56	9·766423	28 82	10·233577	9·857004	28 125	10·142996	10·090581	28 42	9·909419	4	16
30	58	9·766511	29 85	10·233489	9·857137	29 129	10·142863	10·090626	29 44	9·909374	2	30
45	23	9·766598	30 88	10·233402	9·857270	30 133	10·142730	10·090672	30 45	9·909328	37	15
30	2	9·766686	1 3	10·233314	9·857404	1 4	10·142596	10·090717	1 2	9·909283	58	30
46	4	9·766774	2 6	10·233226	9·857537	2 9	10·142463	10·090763	2 3	9·909237	56	14
30	6	9·766862	3 9	10·233138	9·857670	3 13	10·142330	10·090808	3 5	9·909192	54	30
47	8	9·766949	4 12	10·233051	9·857803	4 18	10·142197	10·090854	4 6	9·909146	52	13
30	10	9·767037	5 15	10·232963	9·857936	5 22	10·142064	10·090899	5 8	9·909101	50	30
48	12	9·767124	6 17	10·232876	9·858069	6 27	10·141931	10·090945	6 9	9·909055	48	12
30	14	9·767212	7 20	10·232788	9·858203	7 31	10·141797	10·090991	7 11	9·909009	46	30
49	16	9·767300	8 23	10·232700	9·858336	8 35	10·141664	10·091036	8 12	9·908964	44	11
30	18	9·767387	9 26	10·232613	9·858469	9 40	10·141531	10·091082	9 14	9·908918	42	30
50	20	9·767475	10 29	10·232525	9·858602	10 44	10·141398	10·091127	10 15	9·908873	40	10
30	22	9·767562	11 32	10·232438	9·858735	11 49	10·141265	10·091173	11 17	9·908827	38	30
51	24	9·767649	12 35	10·232351	9·858868	12 53	10·141132	10·091219	12 18	9·908781	36	9
30	26	9·767737	13 38	10·232263	9·859001	13 58	10·140999	10·091264	13 20	9·908736	34	30
52	28	9·767824	14 41	10·232176	9·859134	14 62	10·140866	10·091310	14 21	9·908690	32	8
30	30	9·767912	15 44	10·232088	9·859267	15 66	10·140733	10·091356	15 23	9·908644	30	30
53	32	9·767999	16 47	10·232001	9·859400	16 71	10·140600	10·091401	16 24	9·908599	28	7
30	34	9·768086	17 49	10·231914	9·859533	17 75	10·140467	10·091447	17 26	9·908553	26	30
54	36	9·768173	18 52	10·231827	9·859666	18 80	10·140334	10·091493	18 27	9·908507	24	6
30	38	9·768261	19 55	10·231739	9·859799	19 84	10·140201	10·091538	19 29	9·908462	22	30
55	40	9·768348	20 58	10·231652	9·859932	20 89	10·140068	10·091584	20 30	9·908416	20	5
30	42	9·768435	21 61	10·231565	9·860065	21 93	10·139935	10·091630	21 32	9·908370	18	30
56	44	9·768522	22 64	10·231478	9·860198	22 97	10·139802	10·091676	22 34	9·908324	16	4
30	46	9·768609	23 67	10·231391	9·860331	23 102	10·139669	10·091721	23 35	9·908279	14	30
57	48	9·768697	24 70	10·231303	9·860464	24 106	10·139536	10·091767	24 36	9·908233	12	3
30	50	9·768784	25 73	10·231216	9·860597	25 111	10·139403	10·091813	25 38	9·908187	10	30
58	52	9·768871	26 76	10·231129	9·860730	26 115	10·139270	10·091859	26 40	9·908141	8	2
30	54	9·768958	27 79	10·231042	9·860862	27 120	10·139138	10·091905	27 41	9·908095	6	30
59	56	9·769045	28 81	10·230955	9·860995	28 124	10·139005	10·091951	28 43	9·908049	4	1
30	58	9·769132	29 84	10·230868	9·861128	29 128	10·138872	10·091997	29 44	9·908003	2	30
60	24	9·769219	30 87	10·230781	9·861261	30 133	10·138739	10·092042	30 46	9·907958	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

54° — $3^h\ 36^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2h 24m					36°							
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·769219		10·230781	9·861261		10·138739	10·092042		9·907958	36	60
30	2	9·769306	1″ 3	10·230694	9·861394	1″ 4	10·138606	10·092088	1″ 2	9·907912	58	30
1	4	9·769393	2 6	10·230607	9·861527	2 9	10·138473	10·092134	2 3	9·907866	56	59
30	6	9·769479	3 9	10·230521	9·861659	3 13	10·138341	10·092180	3 5	9·907820	54	30
2	8	9·769566	4 12	10·230434	9·861792	4 18	10·138208	10·092226	4 6	9·907774	52	58
30	10	9·769653	5 14	10·230347	9·861925	5 22	10·138075	10·092272	5 8	9·907728	50	30
3	12	9·769740	6 17	10·230260	9·862058	6 27	10·137942	10·092318	6 9	9·907682	48	57
30	14	9·769827	7 20	10·230173	9·862191	7 31	10·137809	10·092364	7 11	9·907636	46	30
4	16	9·769913	8 23	10·230087	9·862323	8 35	10·137677	10·092410	8 12	9·907590	44	56
30	18	9·770000	9 26	10·230000	9·862456	9 40	10·137544	10·092456	9 14	9·907544	42	30
5	20	9·770087	10 29	10·229913	9·862589	10 44	10·137411	10·092502	10 15	9·907498	40	55
30	22	9·770173	11 32	10·229827	9·862721	11 49	10·137279	10·092548	11 17	9·907452	38	30
6	24	9·770260	12 35	10·229740	9·862854	12 53	10·137146	10·092594	12 18	9·907406	36	54
30	26	9·770347	13 37	10·229653	9·862987	13 57	10·137013	10·092640	13 20	9·907360	34	30
7	28	9·770433	14 40	10·229567	9·863119	14 62	10·136881	10·092686	14 21	9·907314	32	53
30	30	9·770520	15 43	10·229480	9·863252	15 66	10·136748	10·092732	15 23	9·907268	30	30
8	32	9·770606	16 46	10·229394	9·863385	16 71	10·136615	10·092778	16 25	9·907222	28	52
30	34	9·770693	17 49	10·229307	9·863517	17 75	10·136483	10·092825	17 26	9·907175	26	30
9	36	9·770779	18 52	10·229221	9·863650	18 80	10·136350	10·092871	18 28	9·907129	24	51
30	38	9·770866	19 55	10·229134	9·863783	19 84	10·136217	10·092917	19 29	9·907083	22	30
10	40	9·770952	20 58	10·229048	9·863915	20 88	10·136085	10·092963	20 31	9·907037	20	50
30	42	9·771039	21 60	10·228961	9·864048	21 93	10·135952	10·093009	21 32	9·906991	18	30
11	44	9·771125	22 63	10·228875	9·864180	22 97	10·135820	10·093055	22 34	9·906945	16	49
30	46	9·771211	23 66	10·228789	9·864313	23 102	10·135687	10·093102	23 35	9·906898	14	30
12	48	9·771298	24 69	10·228702	9·864445	24 106	10·135555	10·093148	24 37	9·906852	12	48
30	50	9·771384	25 72	10·228616	9·864578	25 110	10·135422	10·093194	25 38	9·906806	10	30
13	52	9·771470	26 75	10·228530	9·864710	26 115	10·135290	10·093240	26 40	9·906760	8	47
30	54	9·771556	27 78	10·228444	9·864843	27 119	10·135157	10·093287	27 41	9·906713	6	30
14	56	9·771643	28 81	10·228357	9·864975	28 124	10·135025	10·093333	28 43	9·906667	4	46
30	58	9·771729	29 84	10·228271	9·865108	29 128	10·134892	10·093379	29 45	9·906621	2	30
15	25	9·771815	30 86	10·228185	9·865240	30 133	10·134760	10·093425	30 46	9·906575	35	45
30	2	9·771901	1 3	10·228099	9·865373	1 4	10·134627	10·093472	1 2	9·906528	58	30
16	4	9·771987	2 6	10·228013	9·865505	2 9	10·134495	10·093518	2 3	9·906482	56	44
30	6	9·772073	3 9	10·227927	9·865638	3 13	10·134362	10·093564	3 5	9·906436	54	30
17	8	9·772159	4 11	10·227841	9·865770	4 18	10·134230	10·093611	4 6	9·906389	52	43
30	10	9·772245	5 14	10·227755	9·865903	5 22	10·134097	10·093657	5 8	9·906343	50	30
18	12	9·772331	6 17	10·227669	9·866035	6 26	10·133965	10·093704	6 9	9·906296	48	42
30	14	9·772417	7 20	10·227583	9·866167	7 31	10·133833	10·093750	7 11	9·906250	46	30
19	16	9·772503	8 23	10·227497	9·866300	8 35	10·133700	10·093796	8 12	9·906204	44	41
30	18	9·772589	9 26	10·227411	9·866432	9 40	10·133568	10·093843	9 14	9·906157	42	30
20	20	9·772675	10 29	10·227325	9·866564	10 44	10·133436	10·093889	10 15	9·906111	40	40
30	22	9·772761	11 32	10·227239	9·866697	11 49	10·133303	10·093936	11 17	9·906064	38	30
21	24	9·772847	12 34	10·227153	9·866829	12 53	10·133171	10·093982	12 19	9·906018	36	39
30	26	9·772933	13 37	10·227067	9·866961	13 57	10·133039	10·094029	13 20	9·905971	34	30
22	28	9·773018	14 40	10·226982	9·867094	14 62	10·132906	10·094075	14 22	9·905925	32	38
30	30	9·773104	15 43	10·226896	9·867226	15 66	10·132774	10·094122	15 23	9·905878	30	30
23	32	9·773190	16 46	10·226810	9·867358	16 71	10·132642	10·094168	16 25	9·905832	28	37
30	34	9·773276	17 49	10·226724	9·867491	17 75	10·132509	10·094215	17 26	9·905785	26	30
24	36	9·773361	18 51	10·226639	9·867623	18 79	10·132377	10·094261	18 28	9·905739	24	36
30	38	9·773447	19 54	10·226553	9·867755	19 84	10·132245	10·094308	19 29	9·905692	22	30
25	40	9·773533	20 57	10·226467	9·867887	20 88	10·132113	10·094355	20 31	9·905645	20	35
30	42	9·773618	21 60	10·226382	9·868019	21 93	10·131981	10·094401	21 33	9·905599	18	30
26	44	9·773704	22 63	10·226296	9·868152	22 97	10·131848	10·094448	22 34	9·905552	16	34
30	46	9·773789	23 66	10·226211	9·868284	23 101	10·131716	10·094494	23 36	9·905506	14	30
27	48	9·773875	24 69	10·226125	9·868416	24 106	10·131584	10·094541	24 37	9·905459	12	33
30	50	9·773960	25 72	10·226040	9·868548	25 110	10·131452	10·094588	25 39	9·905412	10	30
28	52	9·774046	26 74	10·225954	9·868680	26 115	10·131320	10·094634	26 40	9·905366	8	32
30	54	9·774131	27 77	10·225869	9·868813	27 119	10·131187	10·094681	27 42	9·905319	6	30
29	56	9·774217	28 80	10·225783	9·868945	28 123	10·131055	10·094728	28 43	9·905272	4	31
30	58	9·774302	29 83	10·225698	9·869077	29 128	10·130923	10·094775	29 45	9·905225	2	30
30	26	9·774388	30 86	10·225612	9·869209	30 132	10·130791	10·094821	30 46	9·905179	34	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
					53°						3h 34m	

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2h 26m — 36°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·774388		10·225612	9·869209		10·130791	10·094821		9·905179	34	30
30	2	9·774473	1″ 3	10·225527	9·869341	1″ 4	10·130659	10·094868	1″ 2	9·905132	58	30
31	4	9·774558	2 6	10·225442	9·869473	2 9	10·130527	10·094915	2 3	9·905085	56	29
30	6	9·774644	3 8	10·225358	9·869605	3 13	10·130395	10·094962	3 5	9·905038	54	30
32	8	9·774729	4 11	10·225271	9·869737	4 18	10·130263	10·095008	4 6	9·904992	52	28
30	10	9·774814	5 14	10·225186	9·869869	5 22	10·130131	10·095055	5 8	9·904945	50	30
33	12	9·774899	6 17	10·225101	9·870001	6 26	10·129999	10·095102	6 9	9·904898	48	27
30	14	9·774985	7 20	10·225015	9·870133	7 31	10·129867	10·095149	7 11	9·904851	46	30
34	16	9·775070	8 23	10·224930	9·870265	8 35	10·129735	10·095196	8 13	9·904804	44	26
30	18	9·775155	9 25	10·224845	9·870397	9 40	10·129603	10·095243	9 14	9·904757	42	30
35	20	9·775240	10 28	10·224760	9·870529	10 44	10·129471	10·095289	10 16	9·904711	40	25
30	22	9·775325	11 31	10·224675	9·870661	11 48	10·129339	10·095336	11 17	9·904664	38	30
36	24	9·775410	12 34	10·224590	9·870793	12 53	10·129207	10·095383	12 19	9·904617	36	24
30	26	9·775495	13 37	10·224505	9·870925	13 57	10·129075	10·095430	13 20	9·904570	34	30
37	28	9·775580	14 40	10·224420	9·871057	14 62	10·128943	10·095477	14 22	9·904523	32	23
30	30	9·775665	15 42	10·224335	9·871189	15 66	10·128811	10·095524	15 24	9·904476	30	30
38	32	9·775750	16 45	10·224250	9·871321	16 70	10·128679	10·095571	16 25	9·904429	28	22
30	34	9·775835	17 48	10·224165	9·871453	17 75	10·128547	10·095618	17 27	9·904382	26	30
39	36	9·775920	18 51	10·224080	9·871585	18 79	10·128415	10·095665	18 28	9·904335	24	21
30	38	9·776005	19 54	10·223995	9·871717	19 84	10·128283	10·095712	19 30	9·904288	22	30
40	40	9·776090	20 57	10·223910	9·871849	20 88	10·128151	10·095759	20 31	9·904241	20	20
30	42	9·776175	21 59	10·223825	9·871980	21 92	10·128020	10·095806	21 33	9·904194	18	30
41	44	9·776259	22 62	10·223741	9·872112	22 97	10·127888	10·095853	22 34	9·904147	16	19
30	46	9·776344	23 65	10·223656	9·872244	23 101	10·127756	10·095900	23 36	9·904100	14	30
42	48	9·776429	24 68	10·223571	9·872376	24 106	10·127624	10·095947	24 38	9·904053	12	18
30	50	9·776514	25 71	10·223486	9·872508	25 110	10·127492	10·095994	25 39	9·904006	10	30
43	52	9·776598	26 74	10·223402	9·872640	26 114	10·127360	10·096041	26 41	9·903959	8	17
30	54	9·776683	27 76	10·223317	9·872771	27 119	10·127229	10·096088	27 42	9·903912	6	30
44	56	9·776768	28 79	10·223232	9·872903	28 123	10·127097	10·096136	28 44	9·903864	4	16
30	58	9·776852	29 82	10·223148	9·873035	29 128	10·126965	10·096183	29 46	9·903817	2	30
45	**27**	9·776937	30 85	10·223063	9·873167	30 132	10·126833	10·096230	30 47	9·903770	**33**	15
30	2	9·777021	1 3	10·222979	9·873299	1 4	10·126701	10·096277	1 2	9·903723	58	30
46	4	9·777106	2 6	10·222894	9·873430	2 9	10·126570	10·096324	2 3	9·903676	56	14
30	6	9·777191	3 8	10·222809	9·873562	3 13	10·126438	10·096371	3 5	9·903629	54	30
47	8	9·777275	4 11	10·222725	9·873694	4 18	10·126306	10·096419	4 6	9·903581	52	13
30	10	9·777359	5 14	10·222641	9·873825	5 22	10·126175	10·096466	5 8	9·903534	50	30
48	12	9·777444	6 17	10·222556	9·873957	6 26	10·126043	10·096513	6 9	9·903487	48	12
30	14	9·777528	7 20	10·222472	9·874089	7 31	10·125911	10·096560	7 11	9·903440	46	30
49	16	9·777613	8 22	10·222387	9·874220	8 35	10·125780	10·096608	8 13	9·903392	44	11
30	18	9·777697	9 25	10·222303	9·874352	9 40	10·125648	10·096655	9 14	9·903345	42	30
50	20	9·777781	10 28	10·222219	9·874484	10 44	10·125516	10·096702	10 16	9·903298	40	10
30	22	9·777866	11 31	10·222134	9·874615	11 48	10·125385	10·096750	11 17	9·903250	38	30
51	24	9·777950	12 34	10·222050	9·874747	12 53	10·125253	10·096797	12 19	9·903203	36	9
30	26	9·778034	13 37	10·221966	9·874879	13 57	10·125121	10·096844	13 21	9·903156	34	30
52	28	9·778119	14 40	10·221881	9·875010	14 61	10·124990	10·096892	14 22	9·903108	32	8
30	30	9·778203	15 42	10·221797	9·875142	15 66	10·124858	10·096939	15 24	9·903061	30	30
53	32	9·778287	16 45	10·221713	9·875273	16 70	10·124727	10·096986	16 25	9·903014	28	7
30	34	9·778371	17 48	10·221629	9·875405	17 75	10·124595	10·097034	17 27	9·902966	26	30
54	36	9·778455	18 51	10·221545	9·875537	18 79	10·124463	10·097081	18 28	9·902919	24	6
30	38	9·778539	19 53	10·221461	9·875668	19 83	10·124332	10·097129	19 30	9·902871	22	30
55	40	9·778624	20 56	10·221376	9·875800	20 88	10·124200	10·097176	20 32	9·902824	20	5
30	42	9·778708	21 59	10·221292	9·875931	21 92	10·124069	10·097224	21 33	9·902776	18	30
56	44	9·778792	22 62	10·221208	9·876063	22 97	10·123937	10·097271	22 35	9·902729	16	4
30	46	9·778876	23 65	10·221124	9·876194	23 101	10·123806	10·097319	23 36	9·902681	14	30
57	48	9·778960	24 67	10·221040	9·876326	24 105	10·123674	10·097366	24 38	9·902634	12	3
30	50	9·779044	25 70	10·220956	9·876457	25 110	10·123543	10·097414	25 39	9·902586	10	30
58	52	9·779128	26 73	10·220872	9·876589	26 114	10·123411	10·097461	26 41	9·902539	8	2
30	54	9·779211	27 76	10·220789	9·876720	27 119	10·123280	10·097509	27 43	9·902491	6	30
59	56	9·779295	28 79	10·220705	9·876852	28 123	10·123148	10·097556	28 44	9·902444	4	1
30	58	9·779379	29 81	10·220621	9·876983	29 127	10·123017	10·097604	29 46	9·902396	2	30
60	**28**	9·779463	30 84	10·220537	9·877114	30 132	10·122886	10·097651	30 47	9·902349	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

53° — 3h 32m

TABLE XXXVII.—(continued).

LOG. SINES, COSINES, &c.

2h 28m					37°							
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·779463		10·220537	9·877114		10·122886	10·097651		9·902349	32	60
30	2	9·779547	1″ 3	10·220453	9·877246	1 4	10·122754	10·097699	1″ 2	9·902301	58	30
1	4	9·779631	2 6	10·220369	9·877377	2 9	10·122623	10·097747	2 3	9·902253	56	59
30	6	9·779714	3 8	10·220286	9·877509	3 13	10·122491	10·097794	3 5	9·902206	54	30
2	8	9·779798	4 11	10·220202	9·877640	4 17	10·122360	10·097842	4 6	9·902158	52	58
30	10	9·779882	5 14	10·220118	9·877771	5 22	10·122229	10·097890	5 8	9·902110	50	30
3	12	9·779966	6 17	10·220034	9·877903	6 26	10·122097	10·097937	6 10	9·902063	48	57
30	14	9·780049	7 19	10·219951	9·878034	7 31	10·121966	10·097985	7 11	9·902015	46	30
4	16	9·780133	8 22	10·219867	9·878165	8 35	10·121835	10·098033	8 13	9·901967	44	56
30	18	9·780216	9 25	10·219784	9·878297	9 39	10·121703	10·098080	9 14	9·901920	42	30
5	20	9·780300	10 28	10·219700	9·878428	10 44	10·121572	10·098128	10 16	9·901872	40	55
30	22	9·780384	11 31	10·219616	9·878559	11 48	10·121441	10·098176	11 18	9·901824	38	30
6	24	9·780467	12 34	10·219533	9·878691	12 52	10·121309	10·098224	12 19	9·901776	36	54
30	26	9·780551	13 36	10·219449	9·878822	13 57	10·121178	10·098271	13 21	9·901729	34	30
7	28	9·780634	14 39	10·219366	9·878953	14 61	10·121047	10·098319	14 22	9·901681	32	53
30	30	9·780718	15 42	10·219282	9·879085	15 66	10·120915	10·098367	15 24	9·901633	30	30
8	32	9·780801	16 45	10·219199	9·879216	16 70	10·120784	10·098415	16 25	9·901585	28	52
30	34	9·780884	17 47	10·219116	9·879347	17 74	10·120653	10·098463	17 27	9·901537	26	30
9	36	9·780968	18 50	10·219032	9·879478	18 79	10·120522	10·098510	18 29	9·901490	24	51
30	38	9·781051	19 53	10·218949	9·879609	19 83	10·120391	10·098558	19 30	9·901442	22	30
10	40	9·781134	20 56	10·218866	9·879741	20 87	10·120259	10·098606	20 32	9·901394	20	50
30	42	9·781218	21 58	10·218782	9·879872	21 92	10·120128	10·098654	21 33	9·901346	18	30
11	44	9·781301	22 61	10·218699	9·880003	22 96	10·119997	10·098702	22 35	9·901298	16	49
30	46	9·781384	23 64	10·218616	9·880134	23 101	10·119866	10·098750	23 37	9·901250	14	30
12	48	9·781468	24 67	10·218532	9·880265	24 105	10·119735	10·098798	24 38	9·901202	12	48
30	50	9·781551	25 70	10·218449	9·880397	25 109	10·119603	10·098846	25 40	9·901154	10	30
13	52	9·781634	26 73	10·218366	9·880528	26 114	10·119472	10·098894	26 41	9·901106	8	47
30	54	9·781717	27 75	10·218283	9·880659	27 118	10·119341	10·098942	27 43	9·901058	6	30
14	56	9·781800	28 78	10·218200	9·880790	28 122	10·119210	10·098990	28 45	9·901010	4	46
30	58	9·781883	29 81	10·218117	9·880921	29 127	10·119079	10·099038	29 46	9·900962	2	30
15	29	9·781966	30 83	10·218034	9·881052	30 131	10·118948	10·099086	30 48	9·900914	31	45
30	2	9·782049	1 3	10·217951	9·881183	1 4	10·118817	10·099134	1 2	9·900866	58	30
16	4	9·782132	2 6	10·217868	9·881314	2 9	10·118686	10·099182	2 3	9·900818	56	44
30	6	9·782215	3 8	10·217785	9·881445	3 13	10·118555	10·099230	3 5	9·900770	54	30
17	8	9·782298	4 11	10·217702	9·881577	4 17	10·118423	10·099278	4 6	9·900722	52	43
30	10	9·782381	5 14	10·217619	9·881708	5 22	10·118292	10·099326	5 8	9·900674	50	30
18	12	9·782464	6 17	10·217536	9·881839	6 26	10·118161	10·099374	6 10	9·900626	48	42
30	14	9·782547	7 19	10·217453	9·881970	7 31	10·118030	10·099422	7 11	9·900578	46	30
19	16	9·782630	8 22	10·217370	9·882101	8 35	10·117899	10·099471	8 13	9·900529	44	41
30	18	9·782713	9 25	10·217287	9·882232	9 39	10·117768	10·099519	9 14	9·900481	42	30
20	20	9·782796	10 28	10·217204	9·882363	10 44	10·117637	10·099567	10 16	9·900433	40	40
30	22	9·782879	11 30	10·217121	9·882494	11 48	10·117506	10·099615	11 18	9·900385	38	30
21	24	9·782961	12 33	10·217039	9·882625	12 52	10·117375	10·099663	12 19	9·900337	36	39
30	26	9·783044	13 36	10·216956	9·882756	13 57	10·117244	10·099711	13 21	9·900289	34	30
22	28	9·783127	14 39	10·216873	9·882887	14 61	10·117113	10·099760	14 23	9·900240	32	38
30	30	9·783210	15 41	10·216790	9·883018	15 65	10·116982	10·099808	15 24	9·900192	30	30
23	32	9·783292	16 44	10·216708	9·883148	16 70	10·116852	10·099856	16 26	9·900144	28	37
30	34	9·783375	17 47	10·216625	9·883279	17 74	10·116721	10·099904	17 27	9·900096	26	30
24	36	9·783458	18 50	10·216542	9·883410	18 78	10·116590	10·099953	18 29	9·900047	24	36
30	38	9·783540	19 52	10·216460	9·883541	19 83	10·116459	10·100001	19 31	9·899999	22	30
25	40	9·783623	20 55	10·216377	9·883672	20 87	10·116328	10·100049	20 32	9·899951	20	35
30	42	9·783705	21 58	10·216295	9·883803	21 92	10·116197	10·100098	21 34	9·899902	18	30
26	44	9·783788	22 61	10·216212	9·883934	22 96	10·116066	10·100146	22 35	9·899854	16	34
30	46	9·783870	23 63	10·216130	9·884065	23 100	10·115935	10·100194	23 37	9·899806	14	30
27	48	9·783953	24 66	10·216047	9·884196	24 105	10·115804	10·100243	24 39	9·899757	12	33
30	50	9·784035	25 69	10·215965	9·884326	25 109	10·115674	10·100291	25 40	9·899709	10	30
28	52	9·784118	26 72	10·215882	9·884457	26 113	10·115543	10·100340	26 42	9·899660	8	32
30	54	9·784200	27 74	10·215800	9·884588	27 118	10·115412	10·100388	27 43	9·899612	6	30
29	56	9·784282	28 77	10·215718	9·884719	28 122	10·115281	10·100436	28 45	9·899564	4	31
30	58	9·784365	29 80	10·215635	9·884850	29 126	10·115150	10·100485	29 47	9·899515	2	30
30	30	9·784447	30 83	10·215553	9·884980	30 131	10·115020	10·100533	30 48	9·899467	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
					52°						3h 30m	

TABLE XXXVII.—(continued).

LOG. SINES, COSINES, &c.

2ʰ 30ᵐ — 37°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·784447		10·215553	9·884980		10·115020	10·100533		9·899467	30	30
30	2	9·784529	1″ 3	10·215471	9·885111	1″ 4	10·114889	10·100582	1″ 2	9·899418	58	30
31	4	9·784612	2 5	10·215388	9·885242	2 9	10·114758	10·100630	2 3	9·899370	56	29
30	6	9·784694	3 8	10·215306	9·885373	3 13	10·114627	10·100679	3 5	9·899321	54	30
32	8	9·784776	4 11	10·215224	9·885504	4 17	10·114496	10·100727	4 6	9·899273	52	28
30	10	9·784858	5 14	10·215142	9·885634	5 22	10·114366	10·100776	5 8	9·899224	50	30
33	12	9·784941	6 16	10·215059	9·885765	6 26	10·114235	10·100824	6 10	9·899176	48	27
30	14	9·785023	7 19	10·214977	9·885896	7 30	10·114104	10·100873	7 11	9·899127	46	30
34	16	9·785105	8 22	10·214895	9·886026	8 35	10·113974	10·100922	8 13	9·899078	44	26
30	18	9·785187	9 25	10·214813	9·886157	9 39	10·113843	10·100970	9 15	9·899030	42	30
35	20	9·785269	10 27	10·214731	9·886288	10 43	10·113712	10·101019	10 16	9·898981	40	25
30	22	9·785351	11 30	10·214649	9·886419	11 48	10·113581	10·101067	11 18	9·898933	38	30
36	24	9·785433	12 33	10·214567	9·886549	12 52	10·113451	10·101116	12 19	9·898884	36	24
30	26	9·785515	13 36	10·214485	9·886680	13 57	10·113320	10·101165	13 21	9·898835	34	30
37	28	9·785597	14 39	10·214403	9·886811	14 61	10·113189	10·101213	14 23	9·898787	32	23
30	30	9·785679	15 41	10·214321	9·886941	15 65	10·113059	10·101262	15 24	9·898738	30	30
38	32	9·785761	16 44	10·214239	9·887072	16 70	10·112928	10·101311	16 26	9·898689	28	22
30	34	9·785843	17 47	10·214157	9·887202	17 74	10·112798	10·101359	17 28	9·898641	26	30
39	36	9·785925	18 49	10·214075	9·887333	18 78	10·112667	10·101408	18 29	9·898592	24	21
30	38	9·786007	19 52	10·213993	9·887464	19 83	10·112536	10·101457	19 31	9·898543	22	30
40	40	9·786089	20 55	10·213911	9·887594	20 87	10·112406	10·101506	20 32	9·898494	20	20
30	42	9·786170	21 57	10·213830	9·887725	21 91	10·112275	10·101554	21 34	9·898446	18	30
41	44	9·786252	22 60	10·213748	9·887855	22 96	10·112145	10·101603	22 36	9·898397	16	19
30	46	9·786334	23 63	10·213666	9·887986	23 100	10·112014	10·101652	23 37	9·898348	14	30
42	48	9·786416	24 66	10·213584	9·888116	24 104	10·111884	10·101701	24 39	9·898299	12	18
30	50	9·786497	25 68	10·213503	9·888247	25 109	10·111753	10·101750	25 41	9·898250	10	30
43	52	9·786579	26 71	10·213421	9·888378	26 113	10·111622	10·101798	26 42	9·898202	8	17
30	54	9·786661	27 74	10·213339	9·888508	27 117	10·111492	10·101847	27 44	9·898153	6	30
44	56	9·786742	28 77	10·213258	9·888639	28 122	10·111361	10·101896	28 46	9·898104	4	16
30	58	9·786824	29 80	10·213176	9·888769	29 126	10·111231	10·101945	29 47	9·898055	2	30
45	31	9·786906	30 82	10·213094	9·888900	30 130	10·111100	10·101994	30 48	9·898006	29	15
30	2	9·786987	1 3	10·213013	9·889030	1 4	10·110970	10·102043	1 2	9·897957	58	30
46	4	9·787069	2 5	10·212931	9·889161	2 9	10·110839	10·102092	2 3	9·897908	56	14
30	6	9·787150	3 8	10·212850	9·889291	3 13	10·110709	10·102141	3 5	9·897859	54	30
47	8	9·787232	4 11	10·212768	9·889421	4 17	10·110579	10·102190	4 7	9·897810	52	13
30	10	9·787313	5 14	10·212687	9·889552	5 22	10·110448	10·102239	5 8	9·897761	50	30
48	12	9·787395	6 16	10·212605	9·889682	6 26	10·110318	10·102288	6 10	9·897712	48	12
30	14	9·787476	7 19	10·212524	9·889813	7 30	10·110187	10·102337	7 11	9·897663	46	30
49	16	9·787557	8 22	10·212443	9·889943	8 35	10·110057	10·102386	8 13	9·897614	44	11
30	18	9·787639	9 24	10·212361	9·890074	9 39	10·109926	10·102435	9 15	9·897565	42	30
50	20	9·787720	10 27	10·212280	9·890204	10 43	10·109796	10·102484	10 16	9·897516	40	10
30	22	9·787801	11 30	10·212199	9·890334	11 48	10·109666	10·102533	11 18	9·897467	38	30
51	24	9·787883	12 33	10·212117	9·890465	12 52	10·109535	10·102582	12 20	9·897418	36	9
30	26	9·787964	13 35	10·212036	9·890595	13 56	10·109405	10·102631	13 21	9·897369	34	30
52	28	9·788045	14 38	10·211955	9·890725	14 61	10·109275	10·102680	14 23	9·897320	32	8
30	30	9·788127	15 41	10·211873	9·890856	15 65	10·109144	10·102729	15 25	9·897271	30	30
53	32	9·788208	16 43	10·211792	9·890986	16 69	10·109014	10·102778	16 26	9·897222	28	7
30	34	9·788289	17 46	10·211711	9·891116	17 74	10·108884	10·102828	17 28	9·897172	26	30
54	36	9·788370	18 49	10·211630	9·891247	18 78	10·108753	10·102877	18 29	9·897123	24	6
30	38	9·788451	19 51	10·211549	9·891377	19 82	10·108623	10·102926	19 31	9·897074	22	30
55	40	9·788532	20 54	10·211468	9·891507	20 87	10·108493	10·102975	20 33	9·897025	20	5
30	42	9·788613	21 57	10·211387	9·891638	21 91	10·108362	10·103024	21 34	9·896976	18	30
56	44	9·788694	22 60	10·211306	9·891768	22 95	10·108232	10·103074	22 36	9·896926	16	4
30	46	9·788775	23 62	10·211225	9·891898	23 100	10·108102	10·103123	23 38	9·896877	14	30
57	48	9·788856	24 65	10·211144	9·892028	24 104	10·107972	10·103172	24 39	9·896828	12	3
30	50	9·788937	25 68	10·211063	9·892159	25 108	10·107841	10·103221	25 41	9·896779	10	30
58	52	9·789018	26 71	10·210982	9·892289	26 113	10·107711	10·103271	26 42	9·896729	8	2
30	54	9·789099	27 73	10·210901	9·892419	27 117	10·107581	10·103320	27 44	9·896680	6	30
59	56	9·789180	28 76	10·210820	9·892549	28 122	10·107451	10·103369	28 46	9·896631	4	1
30	58	9·789261	29 79	10·210739	9·892680	29 126	10·107320	10·103419	29 48	9·806581	2	30
60	32	9·789342	30 81	10·210658	9·892810	30 130	10·107190	10·103468	30 49	9·896532	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

52° — 3ʰ 28ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

$2^h\ 32^m$ — 38°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·789342		10·210658	9·892810		10·107190	10·103468		9·896532	28	60
30	2	9·789423	1″ 3	10·210577	9·892940	1″ 4	10·107060	10·103517	1″ 2	9·896483	58	30
1	4	9·789504	2 5	10·210496	9·893070	2 9	10·106930	10·103567	2 3	9·896433	56	59
30	6	9·789584	3 8	10·210416	9·893200	3 13	10·106800	10·103616	3 5	9·896384	54	30
2	8	9·789665	4 11	10·210335	9·893331	4 17	10·106669	10·103665	4 7	9·896335	52	58
30	10	9·789746	5 13	10·210254	9·893461	5 22	10·106539	10·103715	5 8	9·896285	50	30
3	12	9·789827	6 16	10·210173	9·893591	6 26	10·106409	10·103764	6 10	9·896236	48	57
30	14	9·789907	7 19	10·210093	9·893721	7 30	10·106279	10·103814	7 12	9·896186	46	30
4	16	9·789988	8 21	10·210012	9·893851	8 35	10·106149	10·103863	8 13	9·896137	44	56
30	18	9·790069	9 24	10·209931	9·893981	9 39	10·106019	10·103913	9 15	9·896087	42	30
5	20	9·790149	10 27	10·209851	9·894111	10 43	10·105889	10·103962	10 16	9·896038	40	55
30	22	9·790230	11 29	10·209770	9·894241	11 48	10·105759	10·104012	11 18	9·895988	38	30
6	24	9·790310	12 32	10·209690	9·894372	12 52	10·105628	10·104061	12 20	9·895939	36	54
30	26	9·790391	13 35	10·209609	9·894502	13 56	10·105498	10·104111	13 21	9·895889	34	30
7	28	9·790471	14 37	10·209529	9·894632	14 61	10·105368	10·104160	14 23	9·895840	32	53
30	30	9·790552	15 40	10·209448	9·894762	15 65	10·105238	10·104210	15 25	9·895790	30	30
8	32	9·790632	16 43	10·209368	9·894892	16 69	10·105108	10·104259	16 26	9·895741	28	52
30	34	9·790713	17 46	10·209287	9·895022	17 74	10·104978	10·104309	17 28	9·895691	26	30
9	36	9·790793	18 48	10·209207	9·895152	18 78	10·104848	10·104359	18 30	9·895641	24	51
30	38	9·790874	19 51	10·209126	9·895282	19 82	10·104718	10·104408	19 31	9·895592	22	30
10	40	9·790954	20 54	10·209046	9·895412	20 87	10·104588	10·104458	20 33	9·895542	20	50
30	42	9·791034	21 56	10·208966	9·895542	21 91	10·104458	10·104507	21 35	9·895493	18	30
11	44	9·791115	22 59	10·208885	9·895672	22 95	10·104328	10·104557	22 36	9·895443	16	49
30	46	9·791195	23 62	10·208805	9·895802	23 100	10·104198	10·104607	23 38	9·895393	14	30
12	48	9·791275	24 65	10·208725	9·895932	24 104	10·104068	10·104657	24 40	9·895343	12	48
30	50	9·791356	25 67	10·208644	9·896062	25 108	10·103938	10·104706	25 41	9·895294	10	30
13	52	9·791436	26 70	10·208564	9·896192	26 113	10·103808	10·104756	26 43	9·895244	8	47
30	54	9·791516	27 72	10·208484	9·896322	27 117	10·103678	10·104806	27 45	9·895194	6	30
14	56	9·791596	28 75	10·208404	9·896452	28 121	10·103548	10·104855	28 46	9·895145	4	46
30	58	9·791676	29 78	10·208324	9·896582	29 126	10·103418	10·104905	29 48	9·895095	2	30
15	**33**	9·791757	30 80	10·208243	9·896712	30 130	10·103288	10·104955	30 50	9·895045	**27**	45
30	2	9·791837	1 3	10·208163	9·896842	1 4	10·103158	10·105005	1 2	9·894995	58	30
16	4	9·791917	2 5	10·208083	9·896971	2 9	10·103029	10·105055	2 3	9·894945	56	44
30	6	9·791997	3 8	10·208003	9·897101	3 13	10·102899	10·105104	3 5	9·894896	54	30
17	8	9·792077	4 11	10·207923	9·897231	4 17	10·102769	10·105154	4 7	9·894846	52	43
30	10	9·792157	5 13	10·207843	9·897361	5 22	10·102639	10·105204	5 8	9·894796	50	30
18	12	9·792237	6 16	10·207763	9·897491	6 26	10·102509	10·105254	6 10	9·894746	48	42
30	14	9·792317	7 19	10·207683	9·897621	7 30	10·102379	10·105304	7 12	9·894696	46	30
19	16	9·792397	8 21	10·207603	9·897751	8 35	10·102249	10·105354	8 13	9·894646	44	41
30	18	9·792477	9 24	10·207523	9·897881	9 39	10·102119	10·105404	9 15	9·894596	42	30
20	20	9·792557	10 27	10·207443	9·898010	10 43	10·101990	10·105454	10 17	9·894546	40	40
30	22	9·792636	11 30	10·207364	9·898140	11 48	10·101860	10·105504	11 18	9·894496	38	30
21	24	9·792716	12 32	10·207284	9·898270	12 52	10·101730	10·105554	12 20	9·894446	36	39
30	26	9·792796	13 35	10·207204	9·898400	13 56	10·101600	10·105604	13 22	9·894396	34	30
22	28	9·792876	14 37	10·207124	9·898530	14 61	10·101470	10·105654	14 23	9·894346	32	38
30	30	9·792956	15 40	10·207044	9·898659	15 65	10·101341	10·105704	15 25	9·894296	30	30
23	32	9·793035	16 43	10·206965	9·898789	16 69	10·101211	10·105754	16 27	9·894246	28	37
30	34	9·793115	17 45	10·206885	9·898919	17 74	10·101081	10·105804	17 28	9·894196	26	30
24	36	9·793195	18 48	10·206805	9·899049	18 78	10·100951	10·105854	18 30	9·894146	24	36
30	38	9·793275	19 51	10·206725	9·899178	19 82	10·100822	10·105904	19 32	9·894096	22	30
25	40	9·793354	20 53	10·206646	9·899308	20 86	10·100692	10·105954	20 33	9·894046	20	35
30	42	9·793434	21 56	10·206566	9·899438	21 91	10·100562	10·106004	21 35	9·893996	18	30
26	44	9·793514	22 59	10·206486	9·899568	22 95	10·100432	10·106054	22 37	9·893946	16	34
30	46	9·793593	23 61	10·206407	9·899697	23 99	10·100303	10·106104	23 38	9·893896	14	30
27	48	9·793673	24 64	10·206327	9·899827	24 104	10·100173	10·106154	24 40	9·893846	12	33
30	50	9·793752	25 67	10·206248	9·899957	25 108	10·100043	10·106205	25 42	9·893795	10	30
28	52	9·793832	26 69	10·206168	9·900087	26 112	10·099913	10·106255	26 43	9·893745	8	32
30	54	9·793911	27 72	10·206089	9·900216	27 117	10·099784	10·106305	27 45	9·893695	6	30
29	56	9·793991	28 74	10·206009	9·900346	28 121	10·099654	10·106355	28 47	9·893645	4	31
30	58	9·794070	29 77	10·205930	9·900475	29 125	10·099524	10·106405	29 48	9·893595	2	30
30	**34**	9·794150	30 80	10·205850	9·900605	30 130	10·099395	10·106456	30 50	9·893544	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

51° — $3^h\ 26^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2h 34m					38°							
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·794150		10·205850	9·900605		10·099395	10·106456		9·893544	26	30
30	2	9·794229	1″ 3	10·205771	9·900735	1″ 4	10·099265	10·106506	1″ 2	9·893494	58	30
31	4	9·794308	2 5	10·205692	9·900864	2 9	10·099136	10·106556	2 3	9·893444	56	29
30	6	9·794388	3 8	10·205612	9·900994	3 13	10·099006	10·106606	3 5	9·893394	54	30
32	8	9·794467	4 11	10·205533	9·901124	4 17	10·098876	10·106657	4 7	9·893343	52	28
30	10	9·794546	5 13	10·205454	9·901253	5 22	10·098747	10·106707	5 8	9·893293	50	30
33	12	9·794626	6 16	10·205374	9·901383	6 26	10·098617	10·106757	6 10	9·893243	48	27
30	14	9·794705	7 19	10·205295	9·901513	7 30	10·098487	10·106808	7 12	9·893192	46	30
34	16	9·794784	8 21	10·205216	9·901642	8 35	10·098358	10·106858	8 13	9·893142	44	26
30	18	9·794863	9 24	10·205137	9·901772	9 39	10·098228	10·106908	9 15	9·893092	42	30
35	20	9·794942	10 26	10·205058	9·901901	10 43	10·098099	10·106959	10 17	9·893041	40	25
30	22	9·795022	11 29	10·204978	9·902031	11 48	10·097969	10·107009	11 18	9·892991	38	30
36	24	9·795101	12 32	10·204899	9·902160	12 52	10·097840	10·107060	12 20	9·892940	36	24
30	26	9·795180	13 34	10·204820	9·902290	13 56	10·097710	10·107110	13 22	9·892890	34	30
37	28	9·795259	14 37	10·204741	9·902420	14 60	10·097580	10·107161	14 24	9·892839	32	23
30	30	9·795338	15 39	10·204662	9·902549	15 65	10·097451	10·107211	15 25	9·892789	30	30
38	32	9·795417	16 42	10·204583	9·902679	16 69	10·097321	10·107261	16 27	9·892739	28	22
30	34	9·795496	17 45	10·204504	9·902808	17 73	10·097192	10·107312	17 29	9·892688	26	30
39	36	9·795575	18 47	10·204425	9·902938	18 78	10·097062	10·107362	18 30	9·892638	24	21
30	38	9·795654	19 50	10·204346	9·903067	19 82	10·096933	10·107413	19 32	9·892587	22	30
40	40	9·795733	20 53	10·204267	9·903197	20 86	10·096803	10·107464	20 34	9·892536	20	20
30	42	9·795812	21 55	10·204188	9·903326	21 91	10·096674	10·107514	21 35	9·892486	18	30
41	44	9·795891	22 58	10·204109	9·903456	22 95	10·096544	10·107565	22 37	9·892435	16	19
30	46	9·795970	23 60	10·204030	9·903585	23 99	10·096415	10·107615	23 39	9·892385	14	30
42	48	9·796049	24 63	10·203951	9·903714	24 104	10·096286	10·107666	24 40	9·892334	12	18
30	50	9·796127	25 66	10·203873	9·903844	25 108	10·096156	10·107716	25 42	9·892284	10	30
43	52	9·796206	26 68	10·203794	9·903973	26 112	10·096027	10·107767	26 44	9·892233	8	17
30	54	9·796285	27 71	10·203715	9·904103	27 117	10·095897	10·107818	27 45	9·892182	6	30
44	56	9·796364	28 74	10·203636	9·904232	28 121	10·095768	10·107868	28 47	9·892132	4	16
30	58	9·796443	29 76	10·203557	9·904362	29 125	10·095638	10·107919	29 49	9·892081	2	30
45	35	9·796521	30 79	10·203479	9·904491	30 130	10·095509	10·107970	30 50	9·892030	25	15
30	2	9·796600	1 3	10·203400	9·904620	1 4	10·095380	10·108020	1 2	9·891980	58	30
46	4	9·796679	2 5	10·203321	9·904750	2 9	10·095250	10·108071	2 3	9·891929	56	14
30	6	9·796757	3 8	10·203243	9·904879	3 13	10·095121	10·108122	3 5	9·891878	54	30
47	8	9·796836	4 10	10·203164	9·905008	4 17	10·094992	10·108173	4 7	9·891827	52	13
30	10	9·796914	5 13	10·203086	9·905138	5 22	10·094862	10·108223	5 8	9·891777	50	30
48	12	9·796993	6 16	10·203007	9·905267	6 26	10·094733	10·108274	6 10	9·891726	48	12
30	14	9·797072	7 18	10·202928	9·905397	7 30	10·094603	10·108325	7 12	9·891675	46	30
49	16	9·797150	8 21	10·202850	9·905526	8 34	10·094474	10·108376	8 14	9·891624	44	11
30	18	9·797229	9 23	10·202771	9·905655	9 39	10·094345	10·108427	9 15	9·891573	42	30
50	20	9·797307	10 26	10·202693	9·905785	10 43	10·094215	10·108477	10 17	9·891523	40	10
30	22	9·797386	11 29	10·202614	9·905914	11 47	10·094086	10·108528	11 19	9·891472	38	30
51	24	9·797464	12 31	10·202536	9·906043	12 52	10·093957	10·108579	12 20	9·891421	36	9
30	26	9·797542	13 34	10·202458	9·906172	13 56	10·093828	10·108630	13 22	9·891370	34	30
52	28	9·797621	14 37	10·202379	9·906302	14 60	10·093698	10·108681	14 24	9·891319	32	8
30	30	9·797699	15 39	10·202301	9·906431	15 65	10·093569	10·108732	15 25	9·891268	30	30
53	32	9·797777	16 42	10·202223	9·906560	16 69	10·093440	10·108783	16 27	9·891217	28	7
30	34	9·797856	17 45	10·202144	9·906690	17 73	10·093310	10·108834	17 29	9·891166	26	30
54	36	9·797934	18 47	10·202066	9·906819	18 78	10·093181	10·108885	18 31	9·891115	24	6
30	38	9·798012	19 50	10·201988	9·906948	19 82	10·093052	10·108936	19 32	9·891064	22	30
55	40	9·798091	20 52	10·201909	9·907077	20 86	10·092923	10·108987	20 34	9·891013	20	5
30	42	9·798169	21 55	10·201831	9·907207	21 91	10·092793	10·109038	21 36	9·890962	18	30
56	44	9·798247	22 58	10·201753	9·907336	22 95	10·092664	10·109089	22 37	9·890911	16	4
30	46	9·798325	23 60	10·201675	9·907465	23 99	10·092535	10·109140	23 39	9·890860	14	30
57	48	9·798403	24 63	10·201597	9·907594	24 103	10·092406	10·109191	24 41	9·890809	12	3
30	50	9·798482	25 65	10·201518	9·907723	25 108	10·092277	10·109242	25 42	9·890758	10	30
58	52	9·798560	26 68	10·201440	9·907853	26 112	10·092147	10·109293	26 44	9·890707	8	2
30	54	9·798638	27 70	10·201362	9·907982	27 116	10·092018	10·109344	27 46	9·890656	6	30
59	56	9·798716	28 73	10·201284	9·908111	28 121	10·091889	10·109395	28 48	9·890605	4	1
30	58	9·798794	29 76	10·201206	9·908240	29 125	10·091760	10·109446	29 49	9·890554	2	30
60	36	9·798872	30 78	10·201128	9·908369	30 129	10·091631	10·109497	30 51	9·890503	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
					51°						3h 24m	

TABLE XXXVII.—(continued).

LOG. SINES, COSINES, &c.

$2^h\ 36^m$ — 39°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·798872		10·201128	9·908369		10·091631	10·109497		9·890503	24	60
30	2	9·798950	1″ 3	10·201050	9·908498	1″ 4	10·091502	10·109549	1″ 2	9·890451	58	30
1	4	9·799028	2 5	10·200972	9·908628	2 9	10·091372	10·109600	2 3	9·890400	56	59
30	6	9·799106	3 8	10·200894	9·908757	3 13	10·091243	10·109651	3 5	9·890349	54	30
2	8	9·799184	4 10	10·200816	9·908886	4 17	10·091114	10·109702	4 7	9·890298	52	58
30	10	9·799262	5 13	10·200738	9·909015	5 21	10·090985	10·109753	5 9	9·890247	50	30
3	12	9·799339	6 16	10·200661	9·909144	6 26	10·090856	10·109805	6 10	9·890195	48	57
30	14	9·799417	7 18	10·200583	9·909273	7 30	10·090727	10·109856	7 12	9·890144	46	30
4	16	9·799495	8 21	10·200505	9·909402	8 34	10·090598	10·109907	8 14	9·890093	44	56
30	18	9·799573	9 23	10·200427	9·909531	9 38	10·090469	10·109958	9 15	9·890042	42	30
5	20	9·799651	10 26	10·200349	9·909660	10 43	10·090340	10·110010	10 17	9·889990	40	55
30	22	9·799728	11 28	10·200272	9·909789	11 47	10·090211	10·110061	11 19	9·889939	38	30
6	24	9·799806	12 31	10·200194	9·909918	12 52	10·090082	10·110112	12 21	9·889888	36	54
30	26	9·799884	13 33	10·200116	9·910048	13 56	10·089952	10·110164	13 22	9·889836	34	30
7	28	9·799962	14 36	10·200038	9·910177	14 60	10·089823	10·110215	14 24	9·889785	32	53
30	30	9·800039	15 38	10·199961	9·910306	15 64	10·089694	10·110266	15 26	9·889734	30	30
8	32	9·800117	16 41	10·199883	9·910435	16 69	10·089565	10·110318	16 27	9·889682	28	52
30	34	9·800195	17 44	10·199805	9·910564	17 73	10·089436	10·110369	17 29	9·889631	26	30
9	36	9·800272	18 47	10·199728	9·910693	18 77	10·089307	10·110421	18 31	9·889579	24	51
30	38	9·800350	19 50	10·199650	9·910822	19 82	10·089178	10·110472	19 32	9·889528	22	30
10	40	9·800427	20 52	10·199573	9·910951	20 86	10·089049	10·110523	20 34	9·889477	20	50
30	42	9·800505	21 55	10·199495	9·911080	21 90	10·088920	10·110575	21 36	9·889425	18	30
11	44	9·800582	22 57	10·199418	9·911209	22 95	10·088791	10·110626	22 38	9·889374	16	49
30	46	9·800660	23 60	10·199340	9·911338	23 99	10·088662	10·110678	23 39	9·889322	14	30
12	48	9·800737	24 62	10·199263	9·911467	24 103	10·088533	10·110729	24 41	9·889271	12	48
30	50	9·800815	25 65	10·199185	9·911596	25 107	10·088404	10·110781	25 43	9·889219	10	30
13	52	9·800892	26 67	10·199108	9·911725	26 112	10·088275	10·110832	26 44	9·889168	8	47
30	54	9·800969	27 70	10·199031	9·911853	27 116	10·088147	10·110884	27 46	9·889116	6	30
14	56	9·801047	28 73	10·198953	9·911982	28 120	10·088018	10·110936	28 48	9·889064	4	46
30	58	9·801124	29 75	10·198876	9·912111	29 125	10·087889	10·110987	29 50	9·889013	2	30
15	37	9·801201	30 78	10·198799	9·912240	30 129	10·087760	10·111039	30 51	9·888961	23	45
30	2	9·801279	1 3	10·198721	9·912369	1 4	10·087631	10·111090	1 2	9·888910	58	30
16	4	9·801356	2 5	10·198644	9·912498	2 9	10·087502	10·111142	2 3	9·888858	56	44
30	6	9·801433	3 8	10·198567	9·912627	3 13	10·087373	10·111194	3 5	9·888806	54	30
17	8	9·801511	4 10	10·198489	9·912756	4 17	10·087244	10·111245	4 7	9·888755	52	43
30	10	9·801588	5 13	10·198412	9·912885	5 21	10·087115	10·111297	5 9	9·888703	50	30
18	12	9·801665	6 15	10·198335	9·913014	6 26	10·086986	10·111349	6 10	9·888651	48	42
30	14	9·801742	7 18	10·198258	9·913143	7 30	10·086857	10·111400	7 12	9·888600	46	30
19	16	9·801819	8 21	10·198181	9·913271	8 34	10·086729	10·111452	8 14	9·888548	44	41
30	18	9·801896	9 23	10·198104	9·913400	9 39	10·086600	10·111504	9 16	9·888496	42	30
20	20	9·801973	10 26	10·198027	9·913529	10 43	10·086471	10·111556	10 17	9·888444	40	40
30	22	9·802051	11 28	10·197949	9·913658	11 47	10·086342	10·111607	11 19	9·888393	38	30
21	24	9·802128	12 31	10·197872	9·913787	12 51	10·086213	10·111659	12 21	9·888341	36	39
30	26	9·802205	13 33	10·197795	9·913916	13 56	10·086084	10·111711	13 22	9·888289	34	30
22	28	9·802282	14 36	10·197718	9·914044	14 60	10·085956	10·111763	14 24	9·888237	32	38
30	30	9·802359	15 38	10·197641	9·914173	15 64	10·085827	10·111815	15 26	9·888185	30	30
23	32	9·802436	16 41	10·197564	9·914302	16 69	10·085698	10·111866	16 28	9·888134	28	37
30	34	9·802512	17 43	10·197488	9·914431	17 73	10·085569	10·111918	17 29	9·888082	26	30
24	36	9·802589	18 46	10·197411	9·914560	18 77	10·085440	10·111970	18 31	9·888030	24	36
30	38	9·802666	19 48	10·197334	9·914688	19 82	10·085312	10·112022	19 33	9·887978	22	30
25	40	9·802743	20 51	10·197257	9·914817	20 86	10·085183	10·112074	20 35	9·887926	20	35
30	42	9·802820	21 54	10·197180	9·914946	21 90	10·085054	10·112126	21 36	9·887874	18	30
26	44	9·802897	22 57	10·197103	9·915075	22 94	10·084925	10·112178	22 38	9·887822	16	34
30	46	9·802974	23 59	10·197026	9·915203	23 99	10·084797	10·112230	23 40	9·887770	14	30
27	48	9·803050	24 62	10·196950	9·915332	24 103	10·084668	10·112282	24 42	9·887718	12	33
30	50	9·803127	25 64	10·196873	9·915461	25 107	10·084539	10·112334	25 43	9·887666	10	30
28	52	9·803204	26 67	10·196796	9·915590	26 112	10·084410	10·112386	26 45	9·887614	8	32
30	54	9·803281	27 69	10·196719	9·915718	27 116	10·084282	10·112438	27 47	9·887562	6	30
29	56	9·803357	28 72	10·196643	9·915847	28 120	10·084153	10·112490	28 48	9·887510	4	31
30	58	9·803434	29 74	10·196566	9·915976	29 124	10·084024	10·112542	29 50	9·887458	2	30
30	38	9·803511	30 77	10·196489	9·916104	30 129	10·083896	10·112594	30 52	9·887406	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

50° — $3^h\ 22^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2ʰ 38ᵐ 39°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·803511		10·196489	9·916104		10·083896	10·112594		9·887406	22	30
30	2	9·803587	1″ 3	10·196413	9·916233	1″ 4	10·083767	10·112646	1″ 2	9·887354	58	30
31	4	9·803664	2 5	10·196336	9·916362	2 9	10·083638	10·112698	2 3	9·887302	56	29
30	6	9·803740	3 8	10·196260	9·916491	3 13	10·083510	10·112750	3 5	9·887250	54	30
32	8	9·803817	4 10	10·196183	9·916619	4 17	10·083381	10·112802	4 7	9·887198	52	28
30	10	9·803893	5 13	10·196107	9·916748	5 21	10·083252	10·112854	5 9	9·887146	50	30
33	12	9·803970	6 15	10·196030	9·916877	6 26	10·083123	10·112907	6 10	9·887093	48	27
30	14	9·804046	7 18	10·195954	9·917005	7 30	10·082995	10·112959	7 12	9·887041	46	30
34	16	9·804123	8 20	10·195877	9·917134	8 34	10·082866	10·113011	8 14	9·886989	44	26
30	18	9·804199	9 23	10·195801	9·917262	9 39	10·082738	10·113063	9 16	9·886937	42	30
35	20	9·804276	10 25	10·195724	9·917391	10 43	10·082609	10·113115	10 17	9·886885	40	25
30	22	9·804352	11 28	10·195648	9·917520	11 47	10·082480	10·113168	11 19	9·886832	38	30
36	24	9·804428	12 30	10·195572	9·917648	12 51	10·082352	10·113220	12 21	9·886780	36	24
30	26	9·804505	13 33	10·195495	9·917777	13 56	10·082223	10·113272	13 23	9·886728	34	30
37	28	9·804581	14 35	10·195419	9·917906	14 60	10·082094	10·113324	14 24	9·886676	32	23
30	30	9·804657	15 38	10·195343	9·918034	15 64	10·081966	10·113377	15 26	9·886623	30	30
38	32	9·804734	16 40	10·195266	9·918163	16 69	10·081837	10·113429	16 28	9·886571	28	22
30	34	9·804810	17 43	10·195190	9·918291	17 73	10·081709	10·113481	17 30	9·886519	26	30
39	36	9·804886	18 46	10·195114	9·918420	18 77	10·081580	10·113534	18 31	9·886466	24	21
30	38	9·804962	19 48	10·195038	9·918548	19 81	10·081452	10·113586	19 33	9·886414	22	30
40	40	9·805039	20 51	10·194961	9·918677	20 86	10·081323	10·113638	20 35	9·886362	20	20
30	42	9·805115	21 53	10·194885	9·918805	21 90	10·081195	10·113691	21 37	9·886309	18	30
41	44	9·805191	22 56	10·194809	9·918934	22 94	10·081066	10·113743	22 38	9·886257	16	19
30	46	9·805267	23 58	10·194733	9·919063	23 99	10·080937	10·113796	23 40	9·886204	14	30
42	48	9·805343	24 61	10·194657	9·919191	24 103	10·080809	10·113848	24 42	9·886152	12	18
30	50	9·805419	25 63	10·194581	9·919320	25 107	10·080680	10·113901	25 44	9·886099	10	30
43	52	9·805495	26 66	10·194505	9·919448	26 111	10·080552	10·113953	26 45	9·886047	8	17
30	54	9·805571	27 68	10·194429	9·919577	27 116	10·080423	10·114005	27 47	9·885995	6	30
44	56	9·805647	28 71	10·194353	9·919705	28 120	10·080295	10·114058	28 49	9·885942	4	16
30	58	9·805723	29 73	10·194277	9·919834	29 124	10·080166	10·114110	29 50	9·885890	2	30
45	39	9·805799	30 76	10·194201	9·919962	30 129	10·080038	10·114163	30 52	9·885837	21	15
30	2	9·805875	1 3	10·194125	9·920091	1 4	10·079909	10·114216	1 2	9·885784	58	30
46	4	9·805951	2 5	10·194049	9·920219	2 9	10·079781	10·114268	2 4	9·885732	56	14
30	6	9·806027	3 8	10·193973	9·920348	3 13	10·079652	10·114321	3 5	9·885679	54	30
47	8	9·806103	4 10	10·193897	9·920476	4 17	10·079524	10·114373	4 7	9·885627	52	13
30	10	9·806179	5 13	10·193821	9·920604	5 21	10·079396	10·114426	5 9	9·885574	50	30
48	12	9·806254	6 15	10·193746	9·920733	6 26	10·079267	10·114478	6 11	9·885522	48	12
30	14	9·806330	7 18	10·193670	9·920861	7 30	10·079139	10·114531	7 12	9·885469	46	30
49	16	9·806406	8 20	10·193594	9·920990	8 34	10·079010	10·114584	8 14	9·885416	44	11
30	18	9·806482	9 23	10·193518	9·921118	9 39	10·078882	10·114636	9 16	9·885364	42	30
50	20	9·806557	10 25	10·193443	9·921247	10 43	10·078753	10·114689	10 18	9·885311	40	10
30	22	9·806633	11 28	10·193367	9·921375	11 47	10·078625	10·114742	11 20	9·885258	38	30
51	24	9·806709	12 30	10·193291	9·921503	12 51	10·078497	10·114795	12 21	9·885205	36	9
30	26	9·806785	13 33	10·193215	9·921632	13 56	10·078368	10·114847	13 23	9·885153	34	30
52	28	9·806860	14 35	10·193140	9·921760	14 60	10·078240	10·114900	14 25	9·885100	32	8
30	30	9·806936	15 38	10·193064	9·921889	15 64	10·078111	10·114953	15 26	9·885047	30	30
53	32	9·807011	16 40	10·192989	9·922017	16 68	10·077983	10·115006	16 28	9·884994	28	7
30	34	9·807087	17 43	10·192913	9·922145	17 73	10·077855	10·115058	17 30	9·884942	26	30
54	36	9·807163	18 45	10·192837	9·922274	18 77	10·077726	10·115111	18 32	9·884889	24	6
30	38	9·807238	19 48	10·192762	9·922402	19 81	10·077598	10·115164	19 33	9·884836	22	30
55	40	9·807314	20 50	10·192686	9·922530	20 86	10·077470	10·115217	20 35	9·884783	20	5
30	42	9·807389	21 53	10·192611	9·922659	21 90	10·077341	10·115270	21 37	9·884730	18	30
56	44	9·807465	22 55	10·192535	9·922787	22 94	10·077213	10·115323	22 39	9·884677	16	4
30	46	9·807540	23 58	10·192460	9·922915	23 98	10·077085	10·115375	23 40	9·884625	14	30
57	48	9·807615	24 60	10·192385	9·923044	24 103	10·076956	10·115428	24 42	9·884572	12	3
30	50	9·807691	25 63	10·192309	9·923172	25 107	10·076828	10·115481	25 44	9·884519	10	30
58	52	9·807766	26 65	10·192234	9·923300	26 111	10·076700	10·115534	26 46	9·884466	8	2
30	54	9·807842	27 68	10·192158	9·923429	27 116	10·076571	10·115587	27 48	9·884413	6	30
59	56	9·807917	28 70	10·192083	9·923557	28 120	10·076443	10·115640	28 49	9·884360	4	1
30	58	9·807992	29 73	10·192008	9·923685	29 124	10·076315	10·115693	29 51	9·884307	2	30
60	40	9·808067	30 76	10·191933	9·923814	30 128	10·076186	10·115746	30 53	9·884254	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

50° 3ʰ 20ᵐ

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

$2^h\ 40^m$ — 40°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·808067		10·191933	9·923814		10·076186	10·115746		9·884254	20	60
30	2	9·808143	1″ 3	10·191857	9·923942	1″ 4	10·076058	10·115799	1″ 2	9·884201	58	30
1	4	9·808218	2 5	10·191782	9·924070	2 9	10·075930	10·115852	2 4	9·884148	56	59
30	6	9·808293	3 8	10·191707	9·924198	3 13	10·075802	10·115905	3 5	9·884095	54	30
2	8	9·808368	4 10	10·191632	9·924327	4 17	10·075673	10·115958	4 7	9·884042	52	58
30	10	9·808444	5 13	10·191556	9·924455	5 21	10·075545	10·116011	5 9	9·883989	50	30
3	12	9·808519	6 15	10·191481	9·924583	6 26	10·075417	10·116064	6 11	9·883936	48	57
30	14	9·808594	7 18	10·191406	9·924711	7 30	10·075289	10·116117	7 12	9·883883	46	30
4	16	9·808669	8 20	10·191331	9·924840	8 34	10·075160	10·116171	8 14	9·883829	44	56
30	18	9·808744	9 23	10·191256	9·924968	9 38	10·075032	10·116224	9 16	9·883776	42	30
5	20	9·808819	10 25	10·191181	9·925096	10 43	10·074904	10·116277	10 18	9·883723	40	55
30	22	9·808894	11 28	10·191106	9·925224	11 47	10·074776	10·116330	11 19	9·883670	38	30
6	24	9·808969	12 30	10·191031	9·925352	12 51	10·074648	10·116383	12 21	9·883617	36	54
30	26	9·809044	13 33	10·190956	9·925481	13 56	10·074519	10·116436	13 23	9·883564	34	30
7	28	9·809119	14 35	10·190881	9·925609	14 60	10·074391	10·116490	14 25	9·883510	32	53
30	30	9·809194	15 38	10·190806	9·925737	15 64	10·074263	10·116543	15 27	9·883457	30	30
8	32	9·809269	16 40	10·190731	9·925865	16 68	10·074135	10·116596	16 28	9·883404	28	52
30	34	9·809344	17 43	10·190656	9·925993	17 73	10·074007	10·116649	17 30	9·883351	26	30
9	36	9·809419	18 45	10·190581	9·926122	18 77	10·073878	10·116703	18 32	9·883297	24	51
30	38	9·809494	19 48	10·190506	9·926250	19 81	10·073750	10·116756	19 34	9·883244	22	30
10	40	9·809569	20 50	10·190431	9·926378	20 85	10·073622	10·116809	20 35	9·883191	20	50
30	42	9·809643	21 53	10·190357	9·926506	21 90	10·073494	10·116863	21 37	9·883137	18	30
11	44	9·809718	22 55	10·190282	9·926634	22 94	10·073366	10·116916	22 39	9·883084	16	49
30	46	9·809793	23 58	10·190207	9·926762	23 98	10·073238	10·116969	23 41	9·883031	14	30
12	48	9·809868	24 60	10·190132	9·926890	24 102	10·073110	10·117023	24 42	9·882977	12	48
30	50	9·809943	25 63	10·190057	9·927019	25 107	10·072981	10·117076	25 44	9·882924	10	30
13	52	9·810017	26 65	10·189983	9·927147	26 111	10·072853	10·117129	26 46	9·882871	8	47
30	54	9·810092	27 68	10·189908	9·927275	27 115	10·072725	10·117183	27 48	9·882817	6	30
14	56	9·810167	28 70	10·189833	9·927403	28 120	10·072597	10·117236	28 50	9·882764	4	46
30	58	9·810241	29 73	10·189759	9·927531	29 124	10·072469	10·117290	29 51	9·882710	2	30
15	41	9·810316	30 75	10·189684	9·927659	30 128	10·072341	10·117343	30 53	9·882657	19	45
30	2	9·810390	1 2	10·189610	9·927787	1 4	10·072213	10·117397	1 2	9·882603	58	30
16	4	9·810465	2 5	10·189535	9·927915	2 9	10·072085	10·117450	2 4	9·882550	56	44
30	6	9·810540	3 7	10·189460	9·928043	3 13	10·071957	10·117504	3 5	9·882496	54	30
17	8	9·810614	4 10	10·189386	9·928171	4 17	10·071829	10·117557	4 7	9·882443	52	43
30	10	9·810689	5 12	10·189311	9·928299	5 21	10·071701	10·117611	5 9	9·882389	50	30
18	12	9·810763	6 15	10·189237	9·928427	6 26	10·071573	10·117664	6 11	9·882336	48	42
30	14	9·810838	7 17	10·189162	9·928555	7 30	10·071445	10·117718	7 13	9·882282	46	30
19	16	9·810912	8 20	10·189088	9·928684	8 34	10·071316	10·117771	8 14	9·882229	44	41
30	18	9·810986	9 22	10·189014	9·928812	9 38	10·071188	10·117825	9 16	9·882175	42	30
20	20	9·811061	10 25	10·188939	9·928940	10 43	10·071060	10·117879	10 18	9·882121	40	40
30	22	9·811135	11 27	10·188865	9·929068	11 47	10·070932	10·117932	11 20	9·882068	38	30
21	24	9·811210	12 30	10·188790	9·929196	12 51	10·070804	10·117986	12 21	9·882014	36	39
30	26	9·811284	13 32	10·188716	9·929324	13 55	10·070676	10·118040	13 23	9·881960	34	30
22	28	9·811358	14 35	10·188642	9·929452	14 60	10·070548	10·118093	14 25	9·881907	32	38
30	30	9·811433	15 37	10·188567	9·929580	15 64	10·070420	10·118147	15 27	9·881853	30	30
23	32	9·811507	16 40	10·188493	9·929708	16 68	10·070292	10·118201	16 29	9·881799	28	37
30	34	9·811581	17 42	10·188419	9·929836	17 73	10·070164	10·118254	17 30	9·881746	26	30
24	36	9·811655	18 45	10·188345	9·929964	18 77	10·070036	10·118308	18 32	9·881692	24	36
30	38	9·811730	19 47	10·188270	9·930092	19 81	10·069908	10·118362	19 34	9·881638	22	30
25	40	9·811804	20 50	10·188196	9·930220	20 85	10·069780	10·118416	20 36	9·881584	20	35
30	42	9·811878	21 52	10·188122	9·930348	21 90	10·069652	10·118470	21 38	9·881530	18	30
26	44	9·811952	22 55	10·188048	9·930475	22 94	10·069525	10·118523	22 39	9·881477	16	34
30	46	9·812026	23 57	10·187974	9·930603	23 98	10·069397	10·118577	23 41	9·881423	14	30
27	48	9·812100	24 60	10·187900	9·930731	24 102	10·069269	10·118631	24 43	9·881369	12	33
30	50	9·812174	25 62	10·187826	9·930859	25 107	10·069141	10·118685	25 45	9·881315	10	30
28	52	9·812248	26 65	10·187752	9·930987	26 111	10·069013	10·118739	26 47	9·881261	8	32
30	54	9·812322	27 67	10·187678	9·931115	27 115	10·068885	10·118793	27 48	9·881207	6	30
29	56	9·812396	28 70	10·187604	9·931243	28 119	10·068757	10·118847	28 50	9·881153	4	31
30	58	9·812470	29 72	10·187530	9·931371	29 124	10·068629	10·118901	29 52	9·881099	2	30
30	42	9·812544	30 74	10·187456	9·931499	30 128	10·068501	10·118954	30 54	9·881046	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

49° — $3^h\ 19^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2h 42m — 40°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·812544		10·187456	9·931499		10·068501	10·118954		9·881046	18	30
30	2	9·812618	1″ 2	10·187382	9·931627	1″ 4	10·068373	10·119008	1″ 2	9·880992	58	30
31	4	9·812692	2 5	10·187308	9·931755	2 9	10·068245	10·119062	2 4	9·880938	56	29
30	6	9·812766	3 7	10·187234	9·931883	3 13	10·068117	10·119116	3 5	9·880884	54	30
32	8	9·812840	4 10	10·187160	9·932010	4 17	10·067990	10·119170	4 7	9·880830	52	28
30	10	9·812914	5 12	10·187086	9·932138	5 21	10·067862	10·119224	5 9	9·880776	50	30
33	12	9·812988	6 15	10·187012	9·932266	6 26	10·067734	10·119278	6 11	9·880722	48	27
30	14	9·813062	7 17	10·186938	9·932394	7 30	10·067606	10·119333	7 13	9·880667	46	30
34	16	9·813135	8 20	10·186865	9·932522	8 34	10·067478	10·119387	8 14	9·880613	44	26
30	18	9·813209	9 22	10·186791	9·932650	9 38	10·067350	10·119441	9 16	9·880559	42	30
35	20	9·813283	10 24	10·186717	9·932778	10 43	10·067222	10·119495	10 18	9·880505	40	25
30	22	9·813357	11 27	10·186643	9·932906	11 47	10·067094	10·119549	11 20	9·880451	38	30
36	24	9·813430	12 29	10·186570	9·933033	12 51	10·066967	10·119603	12 22	9·880397	36	24
30	26	9·813504	13 32	10·186496	9·933161	13 55	10·066839	10·119657	13 24	9·880343	34	30
37	28	9·813578	14 34	10·186422	9·933289	14 60	10·066711	10·119711	14 25	9·880289	32	23
30	30	9·813651	15 37	10·186349	9·933417	15 64	10·066583	10·119766	15 27	9·880234	30	30
38	32	9·813725	16 39	10·186275	9·933545	16 68	10·066455	10·119820	16 29	9·880180	28	22
30	34	9·813799	17 42	10·186201	9·933672	17 72	10·066328	10·119874	17 31	9·880126	26	30
39	36	9·813872	18 44	10·186128	9·933800	18 77	10·066200	10·119928	18 32	9·880072	24	21
30	38	9·813946	19 47	10·186054	9·933928	19 81	10·066072	10·119982	19 34	9·880018	22	30
40	40	9·814019	20 49	10·185981	9·934056	20 85	10·065944	10·120037	20 36	9·879963	20	20
30	42	9·814093	21 51	10·185907	9·934184	21 89	10·065816	10·120091	21 38	9·879909	18	30
41	44	9·814166	22 54	10·185834	9·934311	22 94	10·065689	10·120145	22 40	9·879855	16	19
30	46	9·814240	23 56	10·185760	9·934439	23 98	10·065561	10·120200	23 42	9·879800	14	30
42	48	9·814313	24 59	10·185687	9·934567	24 102	10·065433	10·120254	24 43	9·879746	12	18
30	50	9·814387	25 61	10·185613	9·934695	25 106	10·065305	10·120308	25 45	9·879692	10	30
43	52	9·814460	26 64	10·185540	9·934822	26 111	10·065178	10·120363	26 47	9·879637	8	17
30	54	9·814533	27 66	10·185467	9·934950	27 115	10·065050	10·120417	27 49	9·879583	6	30
44	56	9·814607	28 69	10·185393	9·935078	28 119	10·064922	10·120471	28 51	9·879529	4	16
30	58	9·814680	29 71	10·185320	9·935206	29 124	10·064794	10·120526	29 52	9·879474	2	30
45	43	9·814753	30 74	10·185247	9·935333	30 128	10·064667	10·120580	30 54	9·879420	17	15
30	2	9·814827	1 2	10·185173	9·935461	1 4	10·064539	10·120635	1 2	9·879365	58	30
46	4	9·814900	2 5	10·185100	9·935589	2 9	10·064411	10·120689	2 4	9·879311	56	14
30	6	9·814973	3 7	10·185027	9·935717	3 13	10·064283	10·120743	3 5	9·879257	54	30
47	8	9·815046	4 10	10·184954	9·935844	4 17	10·064156	10·120798	4 7	9·879202	52	13
30	10	9·815120	5 12	10·184880	9·935972	5 21	10·064028	10·120852	5 9	9·879148	50	30
48	12	9·815193	6 15	10·184807	9·936100	6 26	10·063900	10·120907	6 11	9·879093	48	12
30	14	9·815266	7 17	10·184734	9·936227	7 30	10·063773	10·120961	7 13	9·879039	46	30
49	16	9·815339	8 20	10·184661	9·936355	8 34	10·063645	10·121016	8 15	9·878984	44	11
30	18	9·815412	9 22	10·184588	9·936483	9 38	10·063517	10·121071	9 16	9·878929	42	30
50	20	9·815485	10 24	10·184515	9·936611	10 43	10·063389	10·121125	10 18	9·878875	40	10
30	22	9·815558	11 27	10·184442	9·936738	11 47	10·063262	10·121180	11 20	9·878820	38	30
51	24	9·815632	12 29	10·184368	9·936866	12 51	10·063134	10·121234	12 22	9·878766	36	9
30	26	9·815705	13 32	10·184295	9·936994	13 55	10·063006	10·121289	13 24	9·878711	34	30
52	28	9·815778	14 34	10·184222	9·937121	14 60	10·062879	10·121344	14 25	9·878656	32	8
30	30	9·815851	15 36	10·184149	9·937249	15 64	10·062751	10·121398	15 27	9·878602	30	30
53	32	9·815924	16 39	10·184076	9·937377	16 68	10·062623	10·121453	16 29	9·878547	28	7
30	34	9·815996	17 41	10·184004	9·937504	17 72	10·062496	10·121508	17 31	9·878492	26	30
54	36	9·816069	18 44	10·183931	9·937632	18 77	10·062368	10·121562	18 33	9·878438	24	6
30	38	9·816142	19 46	10·183858	9·937759	19 81	10·062241	10·121617	19 35	9·878383	22	30
55	40	9·816215	20 49	10·183785	9·937887	20 85	10·062113	10·121672	20 36	9·878328	20	5
30	42	9·816288	21 51	10·183712	9·938015	21 89	10·061985	10·121727	21 38	9·878273	18	30
56	44	9·816361	22 54	10·183639	9·938142	22 94	10·061858	10·121781	22 40	9·878219	16	4
30	46	9·816434	23 56	10·183566	9·938270	23 98	10·061730	10·121836	23 42	9·878164	14	30
57	48	9·816507	24 58	10·183493	9·938398	24 102	10·061602	10·121891	24 44	9·878109	12	3
30	50	9·816579	25 61	10·183421	9·938525	25 106	10·061475	10·121946	25 46	9·878054	10	30
58	52	9·816652	26 63	10·183348	9·938653	26 111	10·061347	10·122001	26 47	9·877999	8	2
30	54	9·816725	27 66	10·183275	9·938780	27 115	10·061220	10·122055	27 49	9·877945	6	30
59	56	9·816798	28 68	10·183202	9·938908	28 119	10·061092	10·122110	28 51	9·877890	4	1
30	58	9·816870	29 70	10·183130	9·939035	29 123	10·060965	10·122165	29 53	9·877835	2	30
60	44	9·816943	30 73	10·183057	9·939163	30 128	10·060837	10·122220	30 55	9·877780	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

49° — 3h 16m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2h 44m					41°							
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·816943		10·183057	9·939163		10·060837	10·122220		9·877780	16	60
30	2	9·817016	1″ 2	10·182984	9·939291	1″ 4	10·060709	10·122275	1″ 2	9·877725	58	30
1	4	9·817088	2 5	10·182912	9·939418	2 8	10·060582	10·122330	2 4	9·877670	56	59
30	6	9·817161	3 7	10·182839	9·939546	3 13	10·060454	10·122385	3 5	9·877615	54	30
2	8	9·817233	4 10	10·182767	9·939673	4 17	10·060327	10·122440	4 7	9·877560	52	58
30	10	9·817306	5 12	10·182694	9·939801	5 21	10·060199	10·122495	5 9	9·877505	50	30
3	12	9·817379	6 14	10·182621	9·939928	6 25	10·060072	10·122550	6 11	9·877450	48	57
30	14	9·817451	7 17	10·182549	9·940056	7 30	10·059944	10·122605	7 13	9·877395	46	30
4	16	9·817524	8 19	10·182476	9·940183	8 34	10·059817	10·122660	8 15	9·877340	44	56
30	18	9·817596	9 22	10·182404	9·940311	9 38	10·059689	10·122715	9 16	9·877285	42	30
5	20	9·817668	10 24	10·182332	9·940439	10 42	10·059561	10·122770	10 18	9·877230	40	55
30	22	9·817741	11 27	10·182259	9·940566	11 47	10·059434	10·122825	11 20	9·877175	38	30
6	24	9·817813	12 29	10·182187	9·940694	12 51	10·059306	10·122880	12 22	9·877120	36	54
30	26	9·817886	13 32	10·182114	9·940821	13 55	10·059179	10·122935	13 24	9·877065	34	30
7	28	9·817958	14 34	10·182042	9·940949	14 59	10·059051	10·122990	14 26	9·877010	32	53
30	30	9·818030	15 36	10·181970	9·941076	15 64	10·058924	10·123046	15 27	9·876954	30	30
8	32	9·818103	16 39	10·181897	9·941204	16 68	10·058796	10·123101	16 29	9·876899	28	52
30	34	9·818175	17 41	10·181825	9·941331	17 72	10·058669	10·123156	17 31	9·876844	26	30
9	36	9·818247	18 43	10·181753	9·941459	18 76	10·058541	10·123211	18 33	9·876789	24	51
30	38	9·818320	19 46	10·181680	9·941586	19 81	10·058414	10·123266	19 35	9·876734	22	30
10	40	9·818392	20 48	10·181608	9·941713	20 85	10·058287	10·123322	20 37	9·876678	20	50
30	42	9·818464	21 51	10·181536	9·941841	21 89	10·058159	10·123377	21 38	9·876623	18	30
11	44	9·818536	22 53	10·181464	9·941968	22 93	10·058032	10·123432	22 40	9·876568	16	49
30	46	9·818609	23 56	10·181391	9·942096	23 98	10·057904	10·123487	23 42	9·876513	14	30
12	48	9·818681	24 58	10·181319	9·942223	24 102	10·057777	10·123543	24 44	9·876457	12	48
30	50	9·818753	25 61	10·181247	9·942351	25 106	10·057649	10·123598	25 46	9·876402	10	30
13	52	9·818825	26 63	10·181175	9·942478	26 110	10·057522	10·123653	26 48	9·876347	8	47
30	54	9·818897	27 65	10·181103	9·942606	27 115	10·057394	10·123709	27 49	9·876201	6	30
14	56	9·818969	28 68	10·181031	9·942733	28 119	10·057267	10·123764	28 51	9·876236	4	46
30	58	9·819041	29 70	10·180959	9·942861	29 123	10·057139	10·123819	29 53	9·876181	2	30
15	45	9·819113	30 72	10·180887	9·942988	30 127	10·057012	10·123875	30 55	9·876125	15	45
30	2	9·819185	1 2	10·180815	9·943115	1 4	10·056885	10·123930	1 2	9·876070	58	30
16	4	9·819257	2 5	10·180743	9·943243	2 8	10·056757	10·123986	2 4	9·876014	56	44
30	6	9·819329	3 7	10·180671	9·943370	3 13	10·056630	10·124041	3 6	9·875959	54	30
17	8	9·819401	4 10	10·180599	9·943498	4 17	10·056502	10·124096	4 7	9·875904	52	43
30	10	9·819473	5 12	10·180527	9·943625	5 21	10·056375	10·124152	5 9	9·875848	50	30
18	12	9·819545	6 14	10·180455	9·943752	6 25	10·056248	10·124207	6 11	9·875793	48	42
30	14	9·819617	7 17	10·180383	9·943880	7 30	10·056120	10·124263	7 13	9·875737	46	30
19	16	9·819689	8 19	10·180311	9·944007	8 34	10·055993	10·124318	8 15	9·875682	44	41
30	18	9·819761	9 22	10·180239	9·944135	9 38	10·055865	10·124374	9 17	9·875626	42	30
20	20	9·819832	10 24	10·180168	9·944262	10 42	10·055738	10·124429	10 19	9·875571	40	40
30	22	9·819904	11 26	10·180096	9·944389	11 47	10·055611	10·124485	11 20	9·875515	38	30
21	24	9·819976	12 29	10·180024	9·944517	12 51	10·055483	10·124541	12 22	9·875459	36	39
30	26	9·820048	13 31	10·179952	9·944644	13 55	10·055356	10·124596	13 24	9·875404	34	30
22	28	9·820120	14 34	10·179880	9·944771	14 59	10·055229	10·124652	14 26	9·875348	32	38
30	30	9·820191	15 36	10·179809	9·944899	15 64	10·055101	10·124707	15 28	9·875293	30	30
23	32	9·820263	16 38	10·179737	9·945026	16 68	10·054974	10·124763	16 30	9·875237	28	37
30	34	9·820335	17 41	10·179665	9·945153	17 72	10·054847	10·124819	17 31	9·875181	26	30
24	36	9·820406	18 43	10·179594	9·945281	18 76	10·054719	10·124874	18 33	9·875126	24	36
30	38	9·820478	19 46	10·179522	9·945408	19 81	10·054592	10·124930	19 35	9·875070	22	30
25	40	9·820550	20 48	10·179450	9·945535	20 85	10·054465	10·124986	20 37	9·875014	20	35
30	42	9·820621	21 50	10·179379	9·945663	21 89	10·054337	10·125042	21 39	9·874958	18	30
26	44	9·820693	22 53	10·179307	9·945790	22 93	10·054210	10·125097	22 41	9·874903	16	34
30	46	9·820764	23 55	10·179236	9·945917	23 98	10·054083	10·125153	23 43	9·874847	14	30
27	48	9·820836	24 57	10·179164	9·946045	24 102	10·053955	10·125209	24 45	9·874791	12	33
30	50	9·820907	25 60	10·179093	9·946172	25 106	10·053828	10·125265	25 46	9·874735	10	30
28	52	9·820979	26 62	10·179021	9·946299	26 110	10·053701	10·125320	26 48	9·874680	8	32
30	54	9·821050	27 65	10·178950	9·946427	27 115	10·053573	10·125376	27 50	9·874624	6	30
29	56	9·821122	28 67	10·178878	9·946554	28 119	10·053446	10·125432	28 52	9·874568	4	31
30	58	9·821193	29 69	10·178807	9·946681	29 123	10·053319	10·125488	29 54	9·874512	2	30
30	46	9·821265	30 72	10·178735	9·946808	30 127	10·053192	10·125544	30 56	9·874456	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″
					48°						3h 14m	

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

$2^h\ 46^m$ — 41°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·821265		10·178735	9·946808		10·053192	10·125544		9·874456	14	30
30	2	9·821336	1″ 2	10·178664	9·946936	1″ 4	10·053064	10·125600	1″ 2	9·874400	58	30
31	4	9·821407	2 5	10·178593	9·947063	2 8	10·052937	10·125656	2 4	9·874344	56	29
30	6	9·821479	3 7	10·178521	9·947190	3 13	10·052810	10·125712	3 6	9·874288	54	30
32	8	9·821550	4 10	10·178450	9·947318	4 17	10·052682	10·125768	4 7	9·874232	52	28
30	10	9·821621	5 12	10·178379	9·947445	5 21	10·052555	10·125823	5 9	9·874177	50	30
33	12	9·821693	6 14	10·178307	9·947572	6 25	10·052428	10·125879	6 11	9·874121	48	27
30	14	9·821764	7 17	10·178236	9·947699	7 30	10·052301	10·125935	7 13	9·874065	46	30
34	16	9·821835	8 19	10·178165	9·947827	8 34	10·052173	10·125991	8 15	9·874009	44	26
30	18	9·821906	9 21	10·178094	9·947954	9 38	10·052046	10·126047	9 17	9·873953	42	30
35	20	9·821977	10 24	10·178023	9·948081	10 42	10·051919	10·126104	10 19	9·873896	40	25
30	22	9·822049	11 26	10·177951	9·948208	11 47	10·051792	10·126160	11 21	9·873840	38	30
36	24	9·822120	12 28	10·177880	9·948335	12 51	10·051665	10·126216	12 22	9·873784	36	24
30	26	9·822191	13 31	10·177809	9·948463	13 55	10·051537	10·126272	13 24	9·873728	34	30
37	28	9·822262	14 33	10·177738	9·948590	14 59	10·051410	10·126328	14 26	9·873672	32	23
30	30	9·822333	15 36	10·177667	9·948717	15 64	10·051283	10·126384	15 28	9·873616	30	30
38	32	9·822404	16 38	10·177596	9·948844	16 68	10·051156	10·126440	16 30	9·873560	28	22
30	34	9·822475	17 40	10·177525	9·948972	17 72	10·051028	10·126496	17 32	9·873504	26	30
39	36	9·822546	18 43	10·177454	9·949099	18 76	10·050901	10·126552	18 34	9·873448	24	21
30	38	9·822617	19 45	10·177383	9·949226	19 81	10·050774	10·126609	19 36	9·873391	22	30
40	40	9·822688	20 47	10·177312	9·949353	20 85	10·050647	10·126665	20 37	9·873335	20	20
30	42	9·822759	21 50	10·177241	9·949480	21 89	10·050520	10·126721	21 39	9·873279	18	30
41	44	9·822830	22 52	10·177170	9·949608	22 93	10·050392	10·126777	22 41	9·873223	16	19
30	46	9·822901	23 55	10·177099	9·949735	23 98	10·050265	10·126834	23 43	9·873166	14	30
42	48	9·822972	24 57	10·177028	9·949862	24 102	10·050138	10·126890	24 45	9·873110	12	18
30	50	9·823043	25 59	10·176957	9·949989	25 106	10·050011	10·126946	25 47	9·873054	10	30
43	52	9·823114	26 62	10·176886	9·950116	26 110	10·049884	10·127002	26 49	9·872998	8	17
30	54	9·823185	27 64	10·176815	9·950243	27 114	10·049757	10·127059	27 50	9·872941	6	30
44	56	9·823255	28 66	10·176745	9·950371	28 119	10·049629	10·127115	28 52	9·872885	4	16
30	58	9·823326	29 69	10·176674	9·950498	29 123	10·049502	10·127171	29 54	9·872829	2	30
45	47	9·823397	30 71	10·176603	9·950625	30 127	10·049375	10·127228	30 56	9·872772	13	15
30	2	9·823468	1 2	10·176532	9·950752	1 4	10·049248	10·127284	1 2	9·872716	58	30
46	4	9·823539	2 5	10·176461	9·950879	2 8	10·049121	10·127341	2 4	9·872659	56	14
30	6	9·823609	3 7	10·176391	9·951006	3 13	10·048994	10·127397	3 6	9·872603	54	30
47	8	9·823680	4 9	10·176320	9·951133	4 17	10·048867	10·127453	4 8	9·872547	52	13
30	10	9·823751	5 12	10·176249	9·951261	5 21	10·048739	10·127510	5 9	9·872490	50	30
48	12	9·823821	6 14	10·176179	9·951388	6 25	10·048612	10·127566	6 11	9·872434	48	12
30	14	9·823892	7 16	10·176108	9·951515	7 30	10·048485	10·127623	7 13	9·872377	46	30
49	16	9·823963	8 19	10·176037	9·951642	8 34	10·048358	10·127679	8 15	9·872321	44	11
30	18	9·824033	9 21	10·175967	9·951769	9 38	10·048231	10·127736	9 17	9·872264	42	30
50	20	9·824104	10 23	10·175896	9·951896	10 42	10·048104	10·127792	10 19	9·872208	40	10
30	22	9·824174	11 26	10·175826	9·952023	11 47	10·047977	10·127849	11 21	9·872151	38	30
51	24	9·824245	12 28	10·175755	9·952150	12 51	10·047850	10·127905	12 23	9·872095	36	9
30	26	9·824315	13 30	10·175685	9·952277	13 55	10·047723	10·127962	13 25	9·872038	34	30
52	28	9·824386	14 33	10·175614	9·952405	14 59	10·047595	10·128019	14 26	9·871981	32	8
30	30	9·824456	15 35	10·175544	9·952532	15 64	10·047468	10·128075	15 28	9·871925	30	30
53	32	9·824527	16 37	10·175473	9·952659	16 68	10·047341	10·128132	16 30	9·871868	28	7
30	34	9·824597	17 40	10·175403	9·952786	17 72	10·047214	10·128189	17 32	9·871811	26	30
54	36	9·824668	18 42	10·175332	9·952913	18 76	10·047087	10·128245	18 34	9·871755	24	6
30	38	9·824738	19 44	10·175262	9·953040	19 80	10·046960	10·128302	19 36	9·871698	22	30
55	40	9·824808	20 47	10·175192	9·953167	20 85	10·046833	10·128359	20 38	9·871641	20	5
30	42	9·824879	21 49	10·175121	9·953294	21 89	10·046706	10·128415	21 40	9·871585	18	30
56	44	9·824949	22 51	10·175051	9·953421	22 93	10·046579	10·128472	22 42	9·871528	16	4
30	46	9·825019	23 54	10·174981	9·953548	23 97	10·046452	10·128529	23 43	9·871471	14	30
57	48	9·825090	24 56	10·174910	9·953675	24 102	10·046325	10·128586	24 45	9·871414	12	3
30	50	9·825160	25 58	10·174840	9·953802	25 106	10·046198	10·128642	25 47	9·871358	10	30
58	52	9·825230	26 61	10·174770	9·953929	26 110	10·046071	10·128699	26 49	9·871301	8	2
30	54	9·825300	27 63	10·174700	9·954056	27 114	10·045944	10·128756	27 51	9·871244	6	30
59	56	9·825371	28 66	10·174629	9·954183	28 118	10·045817	10·128813	28 53	9·871187	4	1
30	58	9·825441	29 68	10·174559	9·954310	29 123	10·045690	10·128870	29 55	9·871130	2	30
60	48	9·825511	30 71	10·174489	9·954437	30 127	10·045563	10·128927	30 57	9·871073	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

48° — $3^h\ 12^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2h 48m — 42°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·825511		10·174489	9·954437		10·045563	10·128927		9·871073	12	60
30	2	9·825581	1″ 2	10·174419	9·954564	1″ 4	10·045436	10·128983	1″ 2	9·871017	58	30
1	4	9·825651	2 5	10·174349	9·954691	2 8	10·045309	10·129040	2 4	9·870960	56	59
30	6	9·825721	3 7	10·174279	9·954819	3 13	10·045181	10·129097	3 6	9·870903	54	30
2	8	9·825791	4 9	10·174209	9·954946	4 17	10·045054	10·129154	4 8	9·870846	52	58
30	10	9·825861	5 12	10·174139	9·955073	5 21	10·044927	10·129211	5 10	9·870789	50	30
3	12	9·825931	6 14	10·174069	9·955200	6 25	10·044800	10·129268	6 11	9·870732	48	57
30	14	9·826001	7 16	10·173999	9·955327	7 30	10·044673	10·129325	7 13	9·870675	46	30
4	16	9·826071	8 19	10·173929	9·955454	8 34	10·044546	10·129382	8 15	9·870618	44	56
30	18	9·826141	9 21	10·173859	9·955581	9 38	10·044419	10·129439	9 17	9·870561	42	30
5	20	9·826211	10 23	10·173789	9·955708	10 42	10·044292	10·129496	10 19	9·870504	40	55
30	22	9·826281	11 26	10·173719	9·955835	11 47	10·044165	10·129553	11 21	9·870447	38	30
6	24	9·826351	12 28	10·173649	9·955961	12 51	10·044039	10·129610	12 23	9·870390	36	54
30	26	9·826421	13 30	10·173579	9·956088	13 55	10·043912	10·129667	13 25	9·870333	34	30
7	28	9·826491	14 33	10·173509	9·956215	14 59	10·043785	10·129724	14 27	9·870276	32	53
30	30	9·826561	15 35	10·173439	9·956342	15 63	10·043658	10·129782	15 29	9·870218	30	30
8	32	9·826631	16 37	10·173369	9·956469	16 68	10·043531	10·129839	16 30	9·870161	28	52
30	34	9·826701	17 40	10·173299	9·956596	17 72	10·043404	10·129896	17 32	9·870104	26	30
9	36	9·826770	18 42	10·173230	9·956723	18 76	10·043277	10·129953	18 34	9·870047	24	51
30	38	9·826840	19 44	10·173160	9·956850	19 80	10·043150	10·130010	19 36	9·869990	22	30
10	40	9·826910	20 47	10·173090	9·956977	20 85	10·043023	10·130067	20 38	9·869933	20	50
30	42	9·826980	21 49	10·173020	9·957104	21 89	10·042896	10·130125	21 40	9·869875	18	30
11	44	9·827049	22 51	10·172951	9·957231	22 93	10·042769	10·130182	22 42	9·869818	16	49
30	46	9·827119	23 54	10·172881	9·957358	23 97	10·042642	10·130239	23 44	9·869761	14	30
12	48	9·827189	24 56	10·172811	9·957485	24 102	10·042515	10·130296	24 46	9·869704	12	48
30	50	9·827258	25 58	10·172742	9·957612	25 106	10·042388	10·130354	25 48	9·869646	10	30
13	52	9·827328	26 61	10·172672	9·957739	26 110	10·042261	10·130411	26 49	9·869589	8	47
30	54	9·827398	27 63	10·172602	9·957866	27 114	10·042134	10·130468	27 51	9·869532	6	30
14	56	9·827467	28 65	10·172533	9·957993	28 118	10·042007	10·130526	28 53	9·869474	4	46
30	58	9·827537	29 68	10·172463	9·958120	29 123	10·041880	10·130583	29 55	9·869417	2	30
15	49	9·827606	30 70	10·172394	9·958247	30 127	10·041753	10·130640	30 57	9·869360	11	45
30	2	9·827676	1 2	10·172324	9·958373	1 4	10·041627	10·130698	1 2	9·869302	58	30
16	4	9·827745	2 5	10·172255	9·958500	2 8	10·041500	10·130755	2 4	9·869245	56	44
30	6	9·827815	3 7	10·172185	9·958627	3 13	10·041373	10·130812	3 6	9·869188	54	30
17	8	9·827884	4 9	10·172116	9·958754	4 17	10·041246	10·130870	4 8	9·869130	52	43
30	10	9·827954	5 12	10·172046	9·958881	5 21	10·041119	10·130927	5 10	9·869073	50	30
18	12	9·828023	6 14	10·171977	9·959008	6 25	10·040992	10·130985	6 12	9·869015	48	42
30	14	9·828093	7 16	10·171907	9·959135	7 30	10·040865	10·131042	7 13	9·868958	46	30
19	16	9·828162	8 19	10·171838	9·959262	8 34	10·040738	10·131100	8 15	9·868900	44	41
30	18	9·828231	9 21	10·171769	9·959389	9 38	10·040611	10·131157	9 17	9·868843	42	30
20	20	9·828301	10 23	10·171699	9·959516	10 42	10·040484	10·131215	10 19	9·868785	40	40
30	22	9·828370	11 26	10·171630	9·959642	11 47	10·040358	10·131272	11 21	9·868728	38	30
21	24	9·828439	12 28	10·171561	9·959769	12 51	10·040231	10·131330	12 23	9·868670	36	39
30	26	9·828509	13 30	10·171491	9·959896	13 55	10·040104	10·131388	13 25	9·868612	34	30
22	28	9·828578	14 33	10·171422	9·960023	14 59	10·039977	10·131445	14 27	9·868555	32	38
30	30	9·828647	15 35	10·171353	9·960150	15 63	10·039850	10·131503	15 29	9·868497	30	30
23	32	9·828716	16 37	10·171284	9·960277	16 68	10·039723	10·131560	16 31	9·868440	28	37
30	34	9·828786	17 40	10·171214	9·960404	17 72	10·039596	10·131618	17 33	9·868382	26	30
24	36	9·828855	18 42	10·171145	9·960530	18 76	10·039470	10·131676	18 35	9·868324	24	36
30	38	9·828924	19 44	10·171076	9·960657	19 80	10·039343	10·131733	19 36	9·868267	22	30
25	40	9·828993	20 46	10·171007	9·960784	20 85	10·039216	10·131791	20 38	9·868209	20	35
30	42	9·829062	21 49	10·170938	9·960911	21 89	10·039089	10·131849	21 40	9·868151	18	30
26	44	9·829131	22 51	10·170869	9·961038	22 93	10·038962	10·131907	22 42	9·868093	16	34
30	46	9·829200	23 53	10·170800	9·961165	23 97	10·038835	10·131964	23 44	9·868036	14	30
27	48	9·829269	24 55	10·170731	9·961292	24 102	10·038708	10·132022	24 46	9·867978	12	33
30	50	9·829338	25 58	10·170662	9·961418	25 106	10·038582	10·132080	25 48	9·867920	10	30
28	52	9·829407	26 60	10·170593	9·961545	26 110	10·038455	10·132138	26 50	9·867862	8	32
30	54	9·829476	27 62	10·170524	9·961672	27 114	10·038328	10·132196	27 52	9·867804	6	30
29	56	9·829545	28 65	10·170455	9·961799	28 118	10·038201	10·132253	28 54	9·867747	4	31
30	58	9·829614	29 67	10·170386	9·961926	29 123	10·038074	10·132311	29 56	9·867689	2	30
30	50	9·829683	30 60	10·170317	9·962052	30 127	10·037948	10·132369	30 58	9·867631	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

47° — 3h 10m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

$2^h\ 50^m$ — 42°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·829683		10·170317	9·962052		10·037948	10·132369		9·867631	60	30
30	2	9·829752	1″ 2	10·170248	9·962179	1″ 4	10·037821	10·132427	1″ 2	9·867573	58	30
31	4	9·829821	2 5	10·170179	9·962306	2 8	10·037694	10·132485	2 4	9·867515	56	29
30	6	9·829890	3 7	10·170110	9·962433	3 13	10·037567	10·132543	3 6	9·867457	54	30
32	8	9·829959	4 9	10·170041	9·962560	4 17	10·037440	10·132601	4 8	9·867399	52	28
30	10	9·830028	5 12	10·169972	9·962686	5 21	10·037314	10·132659	5 10	9·867341	50	30
33	12	9·830097	6 14	10·169903	9·962813	6 25	10·037187	10·132717	6 12	9·867283	48	27
30	14	9·830165	7 16	10·169835	9·962940	7 30	10·037060	10·132775	7 14	9·867225	46	30
34	16	9·830234	8 19	10·169766	9·963067	8 34	10·036933	10·132833	8 15	9·867167	44	26
30	18	9·830303	9 21	10·169697	9·963194	9 38	10·036806	10·132891	9 17	9·867109	42	30
35	20	9·830372	10 23	10·169628	9·963320	10 42	10·036680	10·132949	10 19	9·867051	40	25
30	22	9·830440	11 25	10·169560	9·963447	11 46	10·036553	10·133007	11 21	9·866993	38	30
36	24	9·830509	12 27	10·169491	9·963574	12 51	10·036426	10·133065	12 23	9·866935	36	24
30	26	9·830578	13 30	10·169422	9·963701	13 55	10·036299	10·133123	13 25	9·866877	34	30
37	28	9·830646	14 32	10·169354	9·963828	14 59	10·036172	10·133181	14 27	9·866819	32	23
30	30	9·830715	15 34	10·169285	9·963954	15 63	10·036046	10·133239	15 29	9·866761	30	30
38	32	9·830784	16 36	10·169216	9·964081	16 68	10·035919	10·133297	16 31	9·866703	28	22
30	34	9·830852	17 39	10·169148	9·964208	17 72	10·035792	10·133356	17 33	9·866644	26	30
39	36	9·830921	18 41	10·169079	9·964335	18 76	10·035665	10·133414	18 35	9·866586	24	21
30	38	9·830989	19 43	10·169011	9·964461	19 80	10·035539	10·133472	19 37	9·866528	22	30
40	40	9·831058	20 46	10·168942	9·964588	20 84	10·035412	10·133530	20 39	9·866470	20	20
30	42	9·831127	21 48	10·168873	9·964715	21 89	10·035285	10·133588	21 41	9·866412	18	30
41	44	9·831195	22 50	10·168805	9·964842	22 93	10·035158	10·133647	22 43	9·866353	16	19
30	46	9·831263	23 52	10·168736	9·964968	23 97	10·035032	10·133705	23 44	9·866295	14	30
42	48	9·831332	24 55	10·168668	9·965095	24 101	10·034905	10·133763	24 46	9·866237	12	18
30	50	9·831400	25 57	10·168600	9·965222	25 105	10·034778	10·133821	25 48	9·866179	10	30
43	52	9·831469	26 59	10·168531	9·965349	26 110	10·034651	10·133880	26 50	9·866120	8	17
30	54	9·831537	27 62	10·168463	9·965475	27 114	10·034525	10·133938	27 52	9·866062	6	30
44	56	9·831606	28 64	10·168394	9·965602	28 118	10·034398	10·133996	28 54	9·866004	4	16
30	58	9·831674	29 66	10·168326	9·965729	29 122	10·034271	10·134055	29 56	9·865945	2	30
45	60	9·831742	30 69	10·168258	9·965855	30 127	10·034145	10·134113	30 58	9·865887	0	15
30	2	9·831811	1 2	10·168189	9·965982	1 4	10·034018	10·134172	1 2	9·865828	58	30
46	4	9·831879	2 5	10·168121	9·966109	2 8	10·033891	10·134230	2 4	9·865770	56	14
30	6	9·831947	3 7	10·168053	9·966236	3 13	10·033764	10·134288	3 6	9·865712	54	30
47	8	9·832015	4 9	10·167985	9·966362	4 17	10·033638	10·134347	4 8	9·865653	52	13
30	10	9·832084	5 12	10·167916	9·966489	5 21	10·033511	10·134405	5 10	9·865595	50	30
48	12	9·832152	6 14	10·167848	9·966616	6 25	10·033384	10·134464	6 12	9·865536	48	12
30	14	9·832220	7 16	10·167780	9·966742	7 30	10·033258	10·134522	7 14	9·865478	46	30
49	16	9·832288	8 19	10·167712	9·966869	8 34	10·033131	10·134581	8 16	9·865419	44	11
30	18	9·832356	9 21	10·167643	9·966996	9 38	10·033004	10·134639	9 18	9·865361	42	30
50	20	9·832425	10 23	10·167575	9·967123	10 42	10·032877	10·134698	10 20	9·865302	40	10
30	22	9·832493	11 25	10·167507	9·967249	11 46	10·032751	10·134756	11 21	9·865244	38	30
51	24	9·832561	12 27	10·167439	9·967376	12 51	10·032624	10·134815	12 23	9·865185	36	9
30	26	9·832629	13 30	10·167371	9·967503	13 55	10·032497	10·134874	13 25	9·865126	34	30
52	28	9·832697	14 32	10·167303	9·967629	14 59	10·032371	10·134932	14 27	9·865068	32	8
30	30	9·832765	15 34	10·167235	9·967756	15 63	10·032244	10·134991	15 29	9·865009	30	30
53	32	9·832833	16 36	10·167167	9·967883	16 68	10·032117	10·135050	16 31	9·864950	28	7
30	34	9·832901	17 39	10·167099	9·968009	17 72	10·031991	10·135108	17 33	9·864892	26	30
54	36	9·832969	18 41	10·167031	9·968136	18 76	10·031864	10·135167	18 35	9·864833	24	6
30	38	9·833037	19 43	10·166963	9·968263	19 80	10·031737	10·135226	19 37	9·864774	22	30
55	40	9·833105	20 45	10·166895	9·968389	20 84	10·031611	10·135284	20 39	9·864716	20	5
30	42	9·833173	21 48	10·166827	9·968516	21 89	10·031484	10·135343	21 41	9·864657	18	30
56	44	9·833241	22 50	10·166759	9·968643	22 93	10·031357	10·135402	22 43	9·864598	16	4
30	46	9·833309	23 52	10·166691	9·968769	23 97	10·031231	10·135461	23 45	9·864539	14	30
57	48	9·833377	24 55	10·166623	9·968896	24 101	10·031104	10·135519	24 47	9·864481	12	3
30	50	9·833444	25 57	10·166556	9·969023	25 106	10·030977	10·135578	25 49	9·864422	10	30
58	52	9·833512	26 59	10·166488	9·969149	26 110	10·030851	10·135637	26 51	9·864363	8	2
30	54	9·833580	27 61	10·166420	9·969276	27 114	10·030724	10·135696	27 53	9·864304	6	30
59	56	9·833648	28 64	10·166352	9·969403	28 118	10·030597	10·135755	28 55	9·864245	4	1
30	58	9·833716	29 66	10·166284	9·969529	29 122	10·030471	10·135814	29 57	9·864186	2	30
60	60	9·833783	30 68	10·166217	9·969656	30 127	10·030344	10·135873	30 59	9·864127	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

47° — $3^h\ 8^m$

TABLE XXXVII.—(continued).

LOG. SINES, COSINES, &c.

$2^h\ 52^m$ 43°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·833783		10·166217	9·969656		10·030344	10·135873		9·864127	8	60
30	2	9·833851	1″ 2	10·166149	9·969783	1″ 4	10·030217	10·135931	1″ 2	9·864069	58	30
1	4	9·833919	2 4	10·166081	9·969909	2 8	10·030091	10·135990	2 4	9·864010	56	59
30	6	9·833986	3 7	10·166014	9·970036	3 13	10·029964	10·136049	3 6	9·863951	54	30
2	8	9·834054	4 9	10·165946	9·970162	4 17	10·029838	10·136108	4 8	9·863892	52	58
30	10	9·834122	5 11	10·165878	9·970289	5 21	10·029711	10·136167	5 10	9·863833	50	30
3	12	9·834189	6 13	10·165811	9·970416	6 25	10·029584	10·136226	6 12	9·863774	48	57
30	14	9·834257	7 16	10·165743	9·970542	7 30	10·029458	10·136285	7 14	9·863715	46	30
4	16	9·834325	8 18	10·165675	9·970669	8 34	10·029331	10·136344	8 16	9·863656	44	56
30	18	9·834392	9 20	10·165608	9·970796	9 38	10·029204	10·136403	9 18	9·863597	42	30
5	20	9·834460	10 22	10·165540	9·970922	10 42	10·029078	10·136462	10 20	9·863538	40	55
30	22	9·834527	11 25	10·165473	9·971049	11 46	10·028951	10·136522	11 22	9·863478	38	30
6	24	9·834595	12 27	10·165405	9·971175	12 51	10·028825	10·136581	12 24	9·863419	36	54
30	26	9·834662	13 29	10·165338	9·971302	13 55	10·028698	10·136640	13 26	9·863360	34	30
7	28	9·834730	14 31	10·165270	9·971429	14 59	10·028571	10·136699	14 28	9·863301	32	53
30	30	9·834797	15 34	10·165203	9·971555	15 63	10·028445	10·136758	15 30	9·863242	30	30
8	32	9·834865	16 36	10·165135	9·971682	16 68	10·028318	10·136817	16 32	9·863183	28	52
30	34	9·834932	17 38	10·165068	9·971808	17 72	10·028192	10·136876	17 33	9·863124	26	30
9	36	9·834999	18 41	10·165001	9·971935	18 76	10·028065	10·136936	18 35	9·863064	24	51
30	38	9·835067	19 43	10·164933	9·972062	19 80	10·027938	10·136995	19 37	9·863005	22	30
10	40	9·835134	20 45	10·164866	9·972188	20 84	10·027812	10·137054	20 39	9·862946	20	50
30	42	9·835201	21 47	10·164799	9·972315	21 89	10·027685	10·137113	21 41	9·862887	18	30
11	44	9·835269	22 49	10·164731	9·972441	22 93	10·027559	10·137173	22 43	9·862827	16	49
30	46	9·835336	23 52	10·164664	9·972568	23 97	10·027432	10·137232	23 45	9·862768	14	30
12	48	9·835403	24 54	10·164597	9·972695	24 101	10·027305	10·137291	24 47	9·862709	12	48
30	50	9·835471	25 56	10·164529	9·972821	25 105	10·027179	10·137350	25 49	9·862650	10	30
13	52	9·835538	26 58	10·164462	9·972948	26 110	10·027052	10·137410	26 51	9·862590	8	47
30	54	9·835605	27 61	10·164395	9·973074	27 114	10·026926	10·137469	27 53	9·862531	6	30
14	56	9·835672	28 63	10·164328	9·973201	28 118	10·026799	10·137529	28 55	9·862471	4	46
30	58	9·835739	29 65	10·164261	9·973327	29 122	10·026673	10·137588	29 57	9·862412	2	30
15	53	9·835807	30 68	10·164193	9·973454	30 126	10·026546	10·137647	30 59	9·862353	7	45
30	2	9·835874	1 2	10·164126	9·973581	1 4	10·026419	10·137707	1 2	9·862293	58	30
16	4	9·835941	2 4	10·164059	9·973707	2 8	10·026293	10·137766	2 4	9·862234	56	44
30	6	9·836008	3 7	10·163992	9·973834	3 13	10·026166	10·137826	3 6	9·862174	54	30
17	8	9·836075	4 9	10·163925	9·973960	4 17	10·026040	10·137885	4 8	9·862115	52	43
30	10	9·836142	5 11	10·163858	9·974087	5 21	10·025913	10·137945	5 10	9·862055	50	30
18	12	9·836209	6 13	10·163791	9·974213	6 25	10·025787	10·138004	6 12	9·861996	48	42
30	14	9·836276	7 16	10·163724	9·974340	7 30	10·025660	10·138064	7 14	9·861936	46	30
19	16	9·836343	8 18	10·163657	9·974466	8 34	10·025534	10·138123	8 16	9·861877	44	41
30	18	9·836410	9 20	10·163590	9·974593	9 38	10·025407	10·138183	9 18	9·861817	42	30
20	20	9·836477	10 22	10·163523	9·974720	10 42	10·025280	10·138242	10 20	9·861758	40	40
30	22	9·836544	11 25	10·163456	9·974846	11 46	10·025154	10·138302	11 22	9·861698	38	30
21	24	9·836611	12 27	10·163389	9·974973	12 51	10·025027	10·138362	12 24	9·861638	36	39
30	26	9·836678	13 29	10·163322	9·975099	13 55	10·024901	10·138421	13 26	9·861579	34	30
22	28	9·836745	14 31	10·163255	9·975226	14 59	10·024774	10·138481	14 28	9·861519	32	38
30	30	9·836812	15 33	10·163188	9·975352	15 63	10·024648	10·138541	15 30	9·861459	30	30
23	32	9·836878	16 36	10·163122	9·975479	16 68	10·024521	10·138600	16 32	9·861400	28	37
30	34	9·836945	17 38	10·163055	9·975605	17 72	10·024395	10·138660	17 34	9·861340	26	30
24	30	9·837012	18 40	10·162988	9·975732	18 76	10·024268	10·138720	18 36	9·861280	24	36
30	38	9·837079	19 42	10·162921	9·975858	19 80	10·024142	10·138779	19 38	9·861221	22	30
25	40	9·837146	20 45	10·162854	9·975985	20 84	10·024015	10·138839	20 40	9·861161	20	35
30	42	9·837212	21 47	10·162788	9·976111	21 89	10·023889	10·138899	21 42	9·861101	18	30
26	44	9·837279	22 49	10·162721	9·976238	22 93	10·023762	10·138959	22 44	9·861041	16	34
30	46	9·837346	23 52	10·162654	9·976364	23 97	10·023636	10·139019	23 46	9·860981	14	30
27	48	9·837412	24 54	10·162588	9·976491	24 101	10·023509	10·139078	24 48	9·860922	12	33
30	50	9·837479	25 56	10·162521	9·976617	25 105	10·023383	10·139138	25 50	9·860862	10	30
28	52	9·837546	26 58	10·162454	9·976744	26 110	10·023256	10·139198	26 52	9·860802	8	32
30	54	9·837612	27 60	10·162388	9·976870	27 114	10·023130	10·139258	27 54	9·860742	6	30
29	56	9·837679	28 63	10·162321	9·976997	28 118	10·023003	10·139318	28 56	9·860682	4	31
30	56	9·837746	29 65	10·162254	9·977123	29 122	10·022877	10·139378	29 58	9·860622	2	30
30	52	9·837812	30 67	10·162188	9·977250	30 126	10·022750	10·139438	30 60	9·860562	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

46° $3^h\ 8^m$

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2h 54m — 43°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·837812		10·162188	9·977250		10·022750	10·139438		9·860562	0	30
30	2	9·837879	1″ 2	10·162121	9·977377	1″ 4	10·022623	10·139498	1″ 2	9·860502	58	30
31	4	9·837945	2 4	10·162055	9·977503	2 8	10·022497	10·139558	2 4	9·860442	56	29
30	6	9·838012	3 7	10·161988	9·977630	3 13	10·022370	10·139618	3 6	9·860382	54	30
32	8	9·838078	4 9	10·161922	9·977756	4 17	10·022244	10·139678	4 8	9·860322	52	28
30	10	9·838145	5 11	10·161855	9·977882	5 21	10·022118	10·139738	5 10	9·860262	50	30
33	12	9·838211	6 13	10·161789	9·978009	6 25	10·021991	10·139798	6 12	9·860202	48	27
30	14	9·838278	7 15	10·161722	9·978135	7 30	10·021865	10·139858	7 14	9·860142	46	30
34	16	9·838344	8 17	10·161656	9·978262	8 34	10·021738	10·139918	8 16	9·860082	44	26
30	18	9·838410	9 20	10·161590	9·978388	9 38	10·021612	10·139978	9 18	9·860022	42	30
35	20	9·838477	10 22	10·161523	9·978515	10 42	10·021485	10·140038	10 20	9·859962	40	25
30	22	9·838543	11 24	10·161457	9·978641	11 46	10·021359	10·140098	11 22	9·859902	38	30
36	24	9·838610	12 27	10·161390	9·978768	12 51	10·021232	10·140158	12 24	9·859842	36	24
30	26	9·838676	13 29	10·161324	9·978894	13 55	10·021106	10·140219	13 26	9·859781	34	30
37	28	9·838742	14 31	10·161258	9·979021	14 59	10·020979	10·140279	14 28	9·859721	32	23
30	30	9·838808	15 33	10·161192	9·979147	15 63	10·020853	10·140339	15 30	9·859661	30	30
38	32	9·838875	16 35	10·161125	9·979274	16 67	10·020726	10·140399	16 32	9·859601	28	22
30	34	9·838941	17 37	10·161059	9·979400	17 72	10·020600	10·140459	17 34	9·859541	26	30
39	36	9·839007	18 40	10·160993	9·979527	18 76	10·020473	10·140520	18 36	9·859480	24	21
30	38	9·839073	19 42	10·160927	9·979653	19 80	10·020347	10·140580	19 38	9·859420	22	30
40	40	9·839140	20 44	10·160860	9·979780	20 84	10·020220	10·140640	20 40	9·859360	20	20
30	42	9·839206	21 46	10·160794	9·979906	21 89	10·020094	10·140700	21 42	9·859300	18	30
41	44	9·839272	22 48	10·160728	9·980033	22 93	10·019967	10·140761	22 44	9·85923[illegible]	16	19
30	46	9·839338	23 51	10·160662	9·980159	23 97	10·019841	10·140821	23 46	9·859179	14	30
42	48	9·839404	24 53	10·160596	9·980286	24 101	10·019714	10·140881	24 48	9·859119	12	18
30	50	9·839470	25 55	10·160530	9·980412	25 105	10·019588	10·140942	25 50	9·859058	10	30
43	52	9·839536	26 57	10·160464	9·980538	26 110	10·019462	10·141002	26 52	9·858998	8	17
30	54	9·839602	27 60	10·160398	9·980665	27 114	10·019335	10·141063	27 54	9·858937	6	30
44	56	9·839668	28 62	10·160332	9·980791	28 118	10·019209	10·141123	28 56	9·858877	4	16
30	58	9·839734	29 64	10·160266	9·980918	29 122	10·019082	10·141183	29 58	9·858817	2	30
45	**55**	9·839800	30 66	10·160200	9·981044	30 126	10·018956	10·141244	30 60	9·858756	**5**	15
30	2	9·839866	1 2	10·160134	9·981171	1 4	10·018829	10·141304	1 2	9·858696	58	30
46	4	9·839932	2 4	10·160068	9·981297	2 8	10·018703	10·141365	2 4	9·858635	56	14
30	6	9·839998	3 7	10·160002	9·981424	3 13	10·018576	10·141425	3 6	9·858575	54	30
47	8	9·840064	4 9	10·159936	9·981550	4 17	10·018450	10·141486	4 8	9·858514	52	13
30	10	9·840130	5 11	10·159870	9·981677	5 21	10·018323	10·141546	5 10	9·858454	50	30
48	12	9·840196	6 13	10·159804	9·981803	6 25	10·018197	10·141607	6 12	9·858393	48	12
30	14	9·840262	7 15	10·159738	9·981929	7 29	10·018071	10·141668	7 14	9·858332	46	30
49	16	9·840328	8 17	10·159672	9·982056	8 34	10·017944	10·141728	8 16	9·858272	44	11
30	18	9·840393	9 20	10·159607	9·982182	9 38	10·017818	10·141789	9 18	9·858211	42	30
50	20	9·840459	10 22	10·159541	9·982309	10 42	10·017691	10·141849	10 20	9·858151	40	10
30	22	9·840525	11 24	10·159475	9·982435	11 46	10·017565	10·141910	11 22	9·858090	38	30
51	24	9·840591	12 26	10·159409	9·982562	12 51	10·017438	10·141971	12 24	9·858029	36	9
30	26	9·840657	13 29	10·159343	9·982688	13 55	10·017312	10·142032	13 26	9·857968	34	30
52	28	9·840722	14 31	10·159278	9·982814	14 59	10·017186	10·142092	14 28	9·857908	32	8
30	30	9·840788	15 33	10·159212	9·982941	15 63	10·017059	10·142153	15 30	9·857847	30	30
53	32	9·840854	16 35	10·159146	9·983067	16 67	10·016933	10·142214	16 32	9·857786	28	7
30	34	9·840919	17 37	10·159081	9·983194	17 72	10·016806	10·142274	17 34	9·857726	26	30
54	36	9·840985	18 39	10·159015	9·983320	18 76	10·016680	10·142335	18 36	9·857665	24	6
30	38	9·841051	19 42	10·158949	9·983447	19 80	10·016553	10·142396	19 38	9·857604	22	30
55	40	9·841116	20 44	10·158884	9·983573	20 84	10·016427	10·142457	20 40	9·857543	20	5
30	42	9·841182	21 46	10·158818	9·983699	21 88	10·016301	10·142518	21 42	9·857482	18	30
56	44	9·841247	22 48	10·158753	9·983826	22 93	10·016174	10·142578	22 45	9·857422	16	4
30	46	9·841313	23 51	10·158687	9·983952	23 97	10·016048	10·142639	23 46	9·857361	14	30
57	48	9·841378	24 53	10·158622	9·984079	24 101	10·015921	10·142700	24 48	9·857300	12	3
30	50	9·841444	25 55	10·158556	9·984205	25 105	10·015795	10·142761	25 51	9·857239	10	30
58	52	9·841509	26 57	10·158491	9·984331	26 109	10·015668	10·142822	26 53	9·857178	8	2
30	54	9·841575	27 59	10·158425	9·984458	27 114	10·015542	10·142883	27 55	9·857117	6	30
59	56	9·841640	28 61	10·158360	9·984584	28 118	10·015416	10·142944	28 57	9·857056	4	1
30	58	9·841706	29 64	10·158294	9·984711	29 122	10·015289	10·143005	29 59	9·856995	2	30
60	**56**	9·841771	30 66	10·158229	9·984837	30 126	10·015163	10·143066	30 61	9·856934	0	0
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

46° — 3h 4m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2h 56m — 44°

′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
0	0	9·841771		10·158229	9·984837		10·015163	10·143066		9·856934	4	60
30	2	9·841837	1″ 2	10·158163	9·984964	1″ 4	10·015036	10·143127	1″ 2	9·856873	58	30
1	4	9·841902	2 4	10·158098	9·985090	2 8	10·014910	10·143188	2 4	9·856812	56	59
30	6	9·841967	3 7	10·158033	9·985216	3 13	10·014784	10·143249	3 6	9·856751	54	30
2	8	9·842033	4 9	10·157967	9·985343	4 17	10·014657	10·143310	4 8	9·856690	52	58
30	10	9·842098	5 11	10·157902	9·985469	5 21	10·014531	10·143371	5 10	9·856629	50	30
3	12	9·842163	6 13	10·157837	9·985596	6 25	10·014404	10·143432	6 12	9·856568	48	57
30	14	9·842229	7 15	10·157771	9·985722	7 29	10·014278	10·143493	7 14	9·856507	46	30
4	16	9·842294	8 17	10·157706	9·985848	8 34	10·014152	10·143554	8 16	9·856446	44	56
30	18	9·842359	9 20	10·157641	9·985975	9 38	10·014025	10·143616	9 18	9·856384	42	30
5	20	9·842424	10 22	10·157576	9·986101	10 42	10·013899	10·143677	10 20	9·856323	40	55
30	22	9·842490	11 24	10·157510	9·986228	11 46	10·013772	10·143738	11 22	9·856262	38	30
6	24	9·842555	12 26	10·157445	9·986354	12 51	10·013646	10·143799	12 24	9·856201	36	54
30	26	9·842620	13 28	10·157380	9·986480	13 55	10·013520	10·143860	13 27	9·856140	34	30
7	28	9·842685	14 30	10·157315	9·986607	14 59	10·013393	10·143922	14 29	9·856078	32	53
30	30	9·842750	15 33	10·157250	9·986733	15 63	10·013267	10·143983	15 31	9·856017	30	30
8	32	9·842815	16 35	10·157185	9·986860	16 67	10·013140	10·144044	16 33	9·855956	28	52
30	34	9·842880	17 37	10·157120	9·986986	17 72	10·013014	10·144106	17 35	9·855895	26	30
9	36	9·842946	18 39	10·157054	9·987112	18 76	10·012888	10·144167	18 37	9·855833	24	51
30	38	9·843011	19 41	10·156989	9·987239	19 80	10·012761	10·144228	19 39	9·855772	22	30
10	40	9·843076	20 43	10·156924	9·987365	20 84	10·012635	10·144289	20 41	9·855711	20	50
30	42	9·843141	21 46	10·156859	9·987491	21 88	10·012509	10·144351	21 43	9·855649	18	30
11	44	9·843206	22 48	10·156794	9·987618	22 93	10·012382	10·144412	22 45	9·855588	16	49
30	46	9·843271	23 50	10·156729	9·987744	23 97	10·012256	10·144474	23 47	9·855526	14	30
12	48	9·843336	24 52	10·156664	9·987871	24 101	10·012129	10·144535	24 49	9·855465	12	48
30	50	9·843401	25 54	10·156599	9·987997	25 105	10·012003	10·144596	25 51	9·855404	10	30
13	52	9·843466	26 56	10·156534	9·988123	26 109	10·011877	10·144658	26 53	9·855342	8	47
30	54	9·843530	27 59	10·156470	9·988250	27 114	10·011750	10·144719	27 55	9·855281	6	30
14	56	9·843595	28 61	10·156405	9·988376	28 118	10·011624	10·144781	28 57	9·855219	4	46
30	58	9·843660	29 63	10·156340	9·988503	29 122	10·011497	10·144842	29 59	9·855158	2	30
15	57	9·843725	30 65	10·156275	9·988629	30 126	10·011371	10·144904	30 61	9·855096	3	45
30	2	9·843790	1 2	10·156210	9·988755	1 4	10·011245	10·144965	1 2	9·855035	58	30
16	4	9·843855	2 4	10·156145	9·988882	2 8	10·011118	10·145027	2 4	9·854973	56	44
30	6	9·843919	3 6	10·156081	9·989008	3 13	10·010992	10·145089	3 6	9·854911	54	30
17	8	9·843984	4 9	10·156016	9·989134	4 17	10·010866	10·145150	4. 8	9·854850	52	43
30	10	9·844049	5 11	10·155951	9·989261	5 21	10·010739	10·145212	5 10	9·854788	50	30
18	12	9·844114	6 13	10·155886	9·989387	6 25	10·010613	10·145273	6 12	9·854727	48	42
30	14	9·844178	7 15	10·155822	9·989513	7 29	10·010487	10·145335	7 14	9·854665	46	30
19	16	9·844243	8 17	10·155757	9·989640	8 34	10·010360	10·145397	8 16	9·854603	44	41
30	18	9·844308	9 19	10·155692	9·989766	9 38	10·010234	10·145458	9 19	9·854542	42	30
20	20	9·844372	10 21	10·155628	9·989893	10 42	10·010107	10·145520	10 21	9·854480	40	40
30	22	9·844437	11 24	10·155563	9·990019	11 46	10·009981	10·145582	11 23	9·854418	38	30
21	24	9·844502	12 26	10·155498	9·990145	12 51	10·009855	10·145644	12 25	9·854356	36	39
30	26	9·844566	13 28	10·155434	9·990272	13 55	10·009728	10·145705	13 27	9·854295	34	30
22	28	9·844631	14 30	10·155369	9·990398	14 59	10·009602	10·145767	14 29	9·854233	32	38
30	30	9·844696	15 32	10·155304	9·990524	15 63	10·009476	10·145829	15 31	9·854171	30	30
23	32	9·844760	16 34	10·155240	9·990651	16 67	10·009349	10·145891	16 33	9·854109	28	37
30	34	9·844825	17 37	10·155175	9·990777	17 72	10·009223	10·145953	17 35	9·854047	26	30
24	36	9·844889	18 39	10·155111	9·990903	18 76	10·009097	10·146014	18 37	9·853986	24	36
30	38	9·844954	19 41	10·155046	9·991030	19 80	10·008970	10·146076	19 39	9·853924	22	30
25	40	9·845018	20 43	10·154982	9·991156	20 84	10·008844	10·146138	20 41	9·853862	20	35
30	42	9·845083	21 45	10·154917	9·991283	21 88	10·008717	10·146200	21 43	9·853800	18	30
26	44	9·845147	22 47	10·154853	9·991409	22 93	10·008591	10·146262	22 45	9·853738	16	34
30	46	9·845211	23 49	10·154789	9·991535	23 97	10·008465	10·146324	23 47	9·853676	14	30
27	48	9·845276	24 52	10·154724	9·991662	24 101	10·008338	10·146386	24 49	9·853614	12	33
30	50	9·845340	25 54	10·154660	9·991788	25 105	10·008212	10·146448	25 51	9·853552	10	30
28	52	9·845405	26 56	10·154595	9·991914	26 109	10·008086	10·146510	26 54	9·853490	8	32
30	54	9·845469	27 58	10·154531	9·992041	27 114	10·007959	10·146572	27 56	9·853428	6	30
29	56	9·845533	28 60	10·154467	9·992167	28 118	10·007833	10·146634	28 58	9·853366	4	31
30	58	9·845598	29 62	10·154402	9·992293	29 122	10·007707	10·146696	29 60	9·853304	2	30
30	58	9·845662	30 64	10·154338	9·992420	30 126	10·007580	10·146758	30 62	9·853242	0	30
′ ″	m. s.	Cosine	Parts	Secant	Cotang.	Parts	Tangent	Cosec.	Parts	Sine	m. s.	′ ″

45° — 3h 2m

TABLE XXXVII.—(*continued*).

LOG. SINES, COSINES, &c.

2h 58m					44°							
′ ″	m. s.	Sine	Parts	Cosec.	Tangent	Parts	Cotang.	Secant	Parts	Cosine	m. s.	′ ″
30	0	9·845662		10·154338	9·992420		10·007580	10·146758		9·853242	60	30
30	2	9·845726	1″ 2	10·154274	9·992546	1″ 4	10·007454	10·146820	1″ 2	9·853180	58	30
31	4	9·845790	2 4	10·154210	9·992672	2 8	10·007328	10·146882	2 4	9·853118	56	29
30	6	9·845855	3 6	10·154145	9·992799	3 13	10·007201	10·146944	3 6	9·853056	54	30
32	8	9·845919	4 8	10·154081	9·992925	4 17	10·007075	10·147006	4 8	9·852994	52	28
30	10	9·845983	5 10	10·154017	9·993051	5 21	10·006949	10·147069	5 10	9·852931	50	30
33	12	9·846047	6 13	10·153953	9·993178	6 25	10·006822	10·147131	6 12	9·852869	48	27
30	14	9·846111	7 15	10·153889	9·993304	7 29	10·006696	10·147193	7 15	9·852807	46	30
34	16	9·846175	8 17	10·153825	9·993430	8 34	10·006570	10·147255	8 17	9·852745	44	26
30	18	9·846240	9 19	10·153760	9·993557	9 38	10·006443	10·147317	9 19	9·852683	42	30
35	20	9·846304	10 21	10·153696	9·993683	10 42	10·006317	10·147380	10 21	9·852620	40	25
30	22	9·846368	11 23	10·153632	9·993810	11 46	10·006190	10·147442	11 23	9·852558	38	30
36	24	9·846432	12 26	10·153568	9·993936	12 51	10·006064	10·147504	12 25	9·852496	36	24
30	26	9·846496	13 28	10·153504	9·994062	13 55	10·005938	10·147566	13 27	9·852434	34	30
37	28	9·846560	14 30	10·153440	9·994189	14 59	10·005811	10·147629	14 29	9·852371	32	23
30	30	9·846624	15 32	10·153376	9·994315	15 63	10·005685	10·147691	15 31	9·852309	30	30
38	32	9·846688	16 34	10·153312	9·994441	16 67	10·005559	10·147753	16 33	9·852247	28	22
30	34	9·846752	17 36	10·153248	9·994568	17 72	10·005432	10·147816	17 35	9·852184	26	30
39	36	9·846816	18 38	10·153184	9·994694	18 76	10·005306	10·147878	18 37	9·852122	24	21
30	38	9·846880	19 40	10·153120	9·994820	19 80	10·005180	10·147941	19 40	9·852059	22	30
40	40	9·846944	20 42	10·153056	9·994947	20 84	10·005053	10·148003	20 42	9·851997	20	20
30	42	9·847008	21 45	10·152992	9·995073	21 88	10·004927	10·148066	21 44	9·851934	18	30
41	44	9·847071	22 47	10·152929	9·995199	22 93	10·094801	10·148128	22 46	9·851872	16	19
30	46	9·847135	23 49	10·152865	9·995326	23 97	10·004674	10·148190	23 48	9·851810	14	30
42	48	9·847199	24 51	10·152801	9·995452	24 101	10·004548	10·148253	24 50	9·851747	12	18
30	50	9·847263	25 53	10·152737	9·995578	25 105	10·004422	10·148315	25 52	9·851685	10	30
43	52	9·847327	26 55	10·152673	9·995705	26 109	10·004295	10·148378	26 54	9·851622	8	17
30	54	9·847391	27 58	10·152609	9·995831	27 114	10·004169	10·148441	27 56	9·851559	6	30
44	56	9·847454	28 60	10·152546	9·995957	28 118	10·004043	10·148503	28 58	9·851497	4	16
30	58	9·847518	29 62	10·152482	9·996084	29 122	10·003916	10·148566	29 60	9·851434	2	30
45	60	9·847582	30 64	10·152418	9·996210	30 126	10·003790	10·148628	30 62	9·851372	0	15
30	2	9·847646	1 2	10·152354	9·996336	1 4	10·003664	10·148691	1 2	9·851309	58	30
46	4	9·847709	2 4	10·152291	9·996463	2 8	10·003537	10·148754	2 4	9·851246	56	14
30	6	9·847773	3 6	10·152227	9·996589	3 13	10·003411	10·148816	3 6	9·851184	54	30
47	8	9·847836	4 8	10·152164	9·996715	4 17	10·003285	10·148879	4 8	9·851121	52	13
30	10	9·847900	5 11	10·152100	9·996842	5 21	10·003158	10·148942	5 10	9·851058	50	30
48	12	9·847964	6 13	10·152036	9·996968	6 25	10·003032	10·149004	6 13	9·850996	48	12
30	14	9·848027	7 15	10·151973	9·997094	7 29	10·002906	10·149067	7 15	9·850933	46	30
49	16	9·848091	8 17	10·151909	9·997221	8 34	10·002779	10·149130	8 17	9·850870	44	11
30	18	9·848155	9 19	10·151845	9·997347	9 38	10·002653	10·149193	9 19	9·850807	42	30
50	20	9·848218	10 21	10·151782	9·997473	10 42	10·002527	10·149255	10 21	9·850745	40	10
30	22	9·848282	11 23	10·151718	9·997600	11 46	10·002400	10·149318	11 23	9·850682	38	30
51	24	9·848345	12 25	10·151655	9·997726	12 51	10·002274	10·149381	12 25	9·850619	36	9
30	26	9·848409	13 28	10·151591	9·997852	13 55	10·002148	10·149444	13 27	9·850556	34	30
52	28	9·848472	14 30	10·151528	9·997979	14 59	10·002021	10·149507	14 29	9·850493	32	8
30	30	9·848535	15 32	10·151465	9·998105	15 63	10·001895	10·149570	15 31	9·850430	30	30
53	32	9·848599	16 34	10·151401	9·998231	16 67	10·001769	10·149632	16 34	9·850368	28	7
30	34	9·848662	17 36	10·151338	9·998358	17 72	10·001642	10·149695	17 36	9·850305	26	30
54	36	9·848726	18 38	10·151274	9·998484	18 76	10·001516	10·149758	18 38	9·850242	24	6
30	38	9·848789	19 40	10·151211	9·998610	19 80	10·001390	10·149821	19 40	9·850179	22	30
55	40	9·848852	20 43	10·151148	9·998737	20 84	10·001263	10·149884	20 42	9·850116	20	5
30	42	9·848916	21 45	10·151084	9·998863	21 88	10·001137	10·149947	21 44	9·850053	18	30
56	44	9·848979	22 47	10·151021	9·998989	22 93	10·001011	10·150010	22 46	9·849990	16	4
30	46	9·849042	23 49	10·150958	9·999116	23 97	10·000884	10·150073	23 48	9·849927	14	30
57	48	9·849106	24 51	10·150894	9·999242	24 101	10·000758	10·150136	24 50	9·849864	12	3
30	50	9·849169	25 53	10·150831	9·999368	25 105	10·000632	10·150199	25 52	9·849801	10	30
58	52	9·849232	26 55	10·150768	9·999495	26 109	10·000505	10·150262	26 54	9·849738	8	2
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ADMISSION OF FELLOWS TO THE ROYAL GEOGRAPHICAL SOCIETY.

Candidates for admission into the Society must be proposed and seconded by Fellows, and it is necessary that the description and residence of such Candidates should be clearly stated on their Certificates.

It is provided by Chapter IV., § 1, of the Regulations, that,

"Every Ordinary Fellow shall, on his election, be required to pay £5 "as his admission fee, and £2 as his first annual subscription, or he may "compound, either at his entrance by one payment of £35, or at any "subsequent period on the following basis:—

Fellows of 20 years' standing and over		.. ..	£12 10*s*.
,, 15 ,, ,,	and under 20	..	£16
,, 10 ,, ,,	,, 15	..	£20

"And no Fellow shall be entitled to vote or to enjoy any other privilege "of the Society so long as he shall continue in arrear."

All subscriptions are payable in advance, on the 1st of January in each year.

The privileges of a Fellow include admission (with one Friend) to all ordinary Meetings of the Society, and the use of the Library and Map-room. Each Fellow is also entitled to Receive a copy of **The Geographical Journal,** which is forwarded, free of expense, to addresses in the United Kingdom or abroad.

Copies of the Regulations and Candidates' Certificates may be had on application at the Society's Office, 1, Savile Row, London, W.

INSTRUCTIONS FOR INTENDING TRAVELLERS.

Instructions for Intending Travellers, under the authority of the Council of the Royal Geographical Society.—Arrangements have been made for the instruction of intending Travellers in the following subjects :—

1. Surveying and Mapping, including the fixing of positions by Astronomical Observations. By Mr. E. A. Reeves, F.R.A.S., Map Curator of the Society.

   Those pupils who have gone through Mr. Reeves's Course, and received a Certificate from him, can obtain instruction in the following additional subjects :—

2. Geology, including practical training in the field. Under the superintendence of the Director-General of the Geological Survey.
3. Botany. Under the superintendence of the Director, Royal Gardens, Kew.
4. Zoology. By Dr. R. Bowdler Sharpe, Natural History Museum, South Kensington.
5. Anthropological Measurements. Under the superintendence of the Anthropological Institute.
6. Photography. By Mr. John Thomson, Author of "Photographic Illustrations of China and its People," and other works.
7. Meteorology. By Dr. H. R. Mill.
8. Outfit and Health. By Charles Forbes Harford, M.A., M.D., Secretary of the Travellers' Health Bureau.

The lessons are given on days and at hours arranged between the Instructor and the pupil.

Tickets for the lessons, at 2*s*. 6*d*. for each hour's lesson, must be previously procured at the Offices of the Society.

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